July 30, 1917.] *Entered as second class matter at the New York, N.Y., Post Office, February 26, 1900.* [No. 235

SCIENCE ABSTRACTS

SECTION A.—PHYSICS.

VOL 20. **Published Monthly.** PART 7

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Issued by the

INSTITUTION OF ELECTRICAL ENGINEERS,

Temporary Offices: 1 ALBEMARLE STREET, LONDON, W. 1.

Compiled and Edited by the Institution, in association with

THE PHYSICAL SOCIETY OF LONDON

With the Co-operation of

THE AMERICAN PHYSICAL SOCIETY

THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, and the

ASSOCIAZIONE ELETTROTECNICA ITALIANA.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JULY 1917.

GENERAL PHYSICS.

571. *Improved High-vacuum Mercury-vapour Pump.* **C. T. Knipp.** (Phys. Rev. 9. pp. 311–313, April, 1917.)—Describes a type of mercury-vapour pump similar in action to the "condensation" pumps recently described by Langmuir [Abs. 89 (1917)]. A diagram of the pump, which is made of glass, is given. The advantages claimed for this form of pump are (i) symmetrical design, which simplifies the glass-blowing; (ii) short delivery tube for the mercury blast; (iii) effective cooling by a proper placing of the water-jacket, ring-seals, and of an internal shielding tube; and (iv) the use of simple mercury valves for the direct return of the condensed mercury-vapour to the boiler. The action of these valves depends on surface tension. The speed of the pump, like all of this type, is much higher than that of Gaede's diffusion pump [Abs. 1178 (1915)]. A. W.

572. *An Ionisation Manometer.* **O. E. Buckley.** (Nat. Acad. Sci., Proc. 2. pp. 683–685, Dec., 1916.)—Hitherto the only manometers for measuring extreme vacua have been the Knudsen manometer and the Langmuir molecular gauge. Both are delicately constructed and slow in action. The new manometer, which makes use of the ionisation of gas by an electron discharge, is free from these objections and also is available over a greater range of pressures. It consists of three electrodes—the kathode, anode, and collector of positive ions. The kathode may be any source of pure electron discharge, *e.g.* Wehnelt kathode or heated metallic filament. The collector is preferably situated between anode and kathode. A milliammeter measures the current to the anode and a sensitive galvanometer that to the collector, which is maintained negative with respect to the kathode and thus picks up only positive ions. If no gas were present in the tube a pure electron current would flow; no current would flow to the collector. When gas is present positive ions are formed in amount proportional to the electron current and to the number of gas molecules present and a certain proportion of the positive ions will flow to the collector. Hence the ratio of the collector current to the anode current is proportional to the pressure and may be used to measure the pressure when the constant of proportionality is known. Experimental tests over a pressure-range from 10^{-3} to 4×10^{-6} mm. of mercury are described. The author suggests several applications of the apparatus for which manometers of other types cannot be readily used. T. H.

573. *Theory of the Flexible-tube Manometer.* **H. Lorenz.** (Phys. Zeits. 18. pp. 117–121, March 15, 1917.)—For measuring the pressure of liquids or elastic fluids in industrial processes, the Bourdon flexible-tube manometer plays an important part. The active component of this instrument is a thin-walled metallic tube of oval, *i.e.* elliptical, cross-section, which is bent into circular shape, the ring, however, not being closed but including an angle of 270°. Both ends are closed by soldered covers, and near the fixed extremity the tube carries a support for attachment to the vessel under examination. Pressure causes deformation of the tube, which deformation is communicated to a calibrated recorder fixed to the movable end.

The present paper deals with the theory of this instrument, and first investigates a closed ring tube possessing a known internal pressure. A previous paper [see Abs. 1335 (1912)] on the bending of curved tubes should be consulted. The distortion produced is found to be directly proportional to the pressure in the flexible tube—a fact which supersedes the previous theory of dependence upon the strength of the tube. Discrepancies between theory and experiment are ascribed to the incomplete elliptical shape of the meridian curve or to the loss of double symmetry on distortion. H. H. Ho.

574. *Movable Divided Circles.* **A. Verschaffel.** (Comptes Rendus, 163. pp. 421–427, Oct. 23, 1916.)—Attention is drawn to the possibility of considerably reducing the probable error of observations made with a divided circle by arranging for it to be movable on its axis, so that readings on a given object may be made on different divisions. C. P. B.

575. *Pressure of High Vacuum by Logarithmic Decrement.* **P. E. Shaw.** (Phys. Soc., Proc. 29. pp. 171–175.; Disc., 175 April, 1917.)—In experiments on the Newtonian constant the author used a torsion balance in a vacuum which ranged from 15 mm. to 0·01 μ. Before the vessel was sealed off the pressure of the vacuum was determined by a McLeod gauge, but after sealing there does not seem to be any ready and accurate method in general use for such a determination. But, by observing the damping of the vibration of the torsion system, the means are at our disposal. The approximate theory required was given by the late J. H. Poynting, and the result may be expressed in the form $P = 35{\cdot}6I\lambda \div saT$; where I is the moment of inertia of suspended system, s the area of surface experiencing the resistance, a its mean distance from centre of rotation, T the period of oscillation, λ the observed logarithmic decrement, P the pressure in mm.

F. J. W. Whipple pointed out reasons for modifying the formula by introduction of a numerical factor. He also pleaded for the use of the millibar, or 1000 dynes/cm.^{2}, for pressures. E. H. B.

576. *Plastic Elongation of Wire.* **A. V. de Forest.** (Mech. Eng. 39. pp. 125–126, Feb. 16, 1917. Paper read before Am. Soc. for Testing Materials. Rev. de Mét. 13E. pp. 266–269, Nov.–Dec., 1916.)—While the tensile stress-strain diagrams of copper, aluminium, nickel, iron, and german-silver wires were found to be smooth curves, that of brass was an irregular one. This is explained on the basis of the amorphous cement theory. After deformation a metal is regarded as being composed of crystalline blocks surrounded and supported by amorphous cement. At room temperature the cement requires a considerable time to set or reach its max. supporting power. It would appear, therefore, that a metal subjected to a gradually increasing dead load would stretch smoothly and uniformly when the rate of stretching

and the temperature were such that the cement would set slowly. Increase of temperature renders the cement less viscous, with the result that the crystalline blocks slip more rapidly and the stress-strain diagram becomes irregular. It has been shown that by increasing the temperature at which the test is made, by decreasing the rate of loading, the stress-strain diagram becomes irregular for phosphor-bronze and brass wire. F. C. A. H. L.

577. *Cohesion.* III. **H. Chatley.** (Phys. Soc., Proc. 29. pp. 206–210, April, 1917.)—In this third paper further evidence is added in favour of an electrical theory of cohesion. *Cohesion* is defined as the net attraction between molecules which are relatively chemically saturated, at distances not greatly exceeding the molecular diameters. *Adhesion* is the special case of cohesion where the molecules are dissimilar in constitution. On the score of magnitude the cohesive attraction fades into chemical affinity (electrostatic linkage) as the proximity increases, and diminishes into Newtonian gravitation as the particles are separated. Pending a better rule the following formula is proposed for the cohesive attraction : $Gm^2/d^{(2+4r)}$, where G is the Newtonian constant of gravitation, m the mass of the molecules, d the molecular interval (centre to centre), and r the ratio of the molecular diameter to this interval. At absolute zero $r = 1$, the exponent of d becomes 6, and the cohesion is GS^2, where S is the density.

This formula gives a bond descending from about one-hundredth of the electrostatic force to the ordinary Newtonian values as the proximity changes from contact to about ten molecular diameters. [See Abs. 1189 (1916).] E. H. B.

578. *Evaporation and Adsorption.* **A. Schidlof.** (Archives des Sciences, 43. pp. 217–244, March, 1917.)—Gives a theory of the phenomena of continuous variation of the mass and of the density of drops of mercury maintained in suspension in a gas.

The hypothesis of molecular bombardment leads to the supposition of a film or layer of adsorption covering the surface of a liquid which is in the presence of a gas. The supposition of this layer of adsorption, combined with that of the molecular bombardment, suffices to explain the whole of the facts observed by A. Targonski [see Abs. 1569 (1914)]. E. H. B.

579. *Equivalent Mass in Rigid Dynamics.* **A. F. Zahm** and **W. P. Loo.** (Frank. Inst., J. 183. pp. 207–210, Feb., 1917.)—In the analysis of the motion of a rigid body, the forces acting upon it may be replaced by three components along the principal axes through its centroid, and three couples about those axes. Then the translation of the centroid is determined from the mass and the three component forces; the rotation about the centroid, from the principal moments of inertia and the component couples. Hence the actual body may be replaced in analysis by some kinetic equivalent. That here given is a set of three pairs of particles, each of one-sixth the total mass and so placed as to give the required moments of inertia. Applications are made to gyroscopes and to screw propellers. E. H. B.

580. *Motion of a Sphere in a Viscous Medium bounded by Parallel Walls.* **A. Westgren.** (Ann. d. Physik, 52. 3. pp. 308–322, April 3, 1917.)—This experimental research was conducted by allowing and observing the fall in water of suspended spherules of gamboge and gum-mastic. The densities of these materials are not greatly different from that of water; hence their speeds were small.

The final result reached is that the frictional resistance F of the gum-mastic and gamboge spherules of radius a when falling in water midway between two parallel walls $2l$ apart is expressed by $F = F_\infty(1 + ka^2l^2)$, where F_∞ denotes the resistance in an unlimited medium. For the constant k is found the value $3{\cdot}4 \pm 0{\cdot}34$. E. H. B.

581. *Dropping of Liquids from the ends of Cylindrical Tubes.* **L. Abonnenc.** (Comptes Rendus, 164. pp. 402–404, March 5, 1917.)—Vaillant has shown [Abs. 1612 (1915)] that when a liquid falls in drops from the end of a cylindrical tube, the weight p of the drops is a parabolic function of the frequency of fall of the form $p = \alpha D + m\beta N - n\gamma N^2/d$. Here β and γ are constants whose values are respectively 4·20 and 0·0157 ; N is the number of drops in 100 secs., p the weight of a drop in tenths of a milligramme, and D and d are the external and internal diams. of the tube, the experiments being made with water at 20° C. m and n are two quantities which in the experiments described (D = 2 to 7 mm.) take the values 1 and 2. α is a constant depending on m. For $m = 1$, $\alpha = 1570$, while for $m = 2$, $\alpha = 1420$. The author of the present paper has extended the experiments for water to tubes of external diam. less than 2 mm., and for other liquids flowing from tubes of any diameter. Putting the above relation in the form $p = a + bN - cN^2$, the constants a, b and c were determined for a number of tubes of diam. less than 2 mm., and from these results it appears that for such tubes $m = 0{\cdot}5$, $n = 0{\cdot}5$, and α oscillates about the value $\alpha = 1720$. The results obtained for tubes of large internal diam. are not so reliable, but it appears that for a certain frequency, which varies with the internal diam., a sudden change occurs in the conditions of fall of the drops, characterised by an abrupt alteration of the values m and n. It is noteworthy that the values of α corresponding to the values $m = 2$, $m = 1$, and $m = \frac{1}{2}$ show a difference, nearly constant, which is about double the value of the surface tension of water. A. W.

582. *Use of the Pyranometer.* **C. G. Abbot** and **L. B. Aldrich.** (Smithsonian Misc. Coll. 66. pp. 1–9, Nov., 1916.)—The instrument has already been described [Abs. 1322 (1916)]. The present paper describes a new method of taking the readings which not only saves time but leads to greater accuracy. Measurements of inward day radiation and outward night radiation made on Mount Wilson are given. J. S. Di.

583. *The Foundations of Modern Physics.* **E. Guillaume.** (Archives des Sciences, 43. pp. 5–21, Jan. ; 89–112, Feb., and pp. 185–198, March, 1917.)—A general paper in which the changes necessitated as a result of the introduction of modern theories of gravitation and relativity are considered. L. H. W.

584. *Comparison of Callendar Sunshine Recorder and Ångström Pyrheliometer.* **J. Patterson.** (Roy. Soc. Canada, Trans. 10. pp. 51–55, Sept., 1916.)—Comparative readings were taken with (*a*) a normal Ångström pyrheliometer, (*b*) a similar instrument having the receiver covered with a glass bulb of the type used in the Callendar, and (*c*) a Callendar Recorder. The results from one day's readings are shown graphically. These are typical of all days. The normal Ångström gives the highest readings. The shielded Ångström gives about 10 % lower throughout most of the day, but towards sunset this percentage error decreases. The Callendar Recorder gives close agreement with the shielded Ångström in the morning, but during the afternoon the readings increase relatively and towards evening exceed those of

the normal Ångström. In these experiments the Callendar was mounted normal to the incident sunlight and shielded from sky radiation. The comparisons which have been made with the Callendar show the desirability of standardising its readings by laboratory investigation. [See Abs. 400 (1915) and 20 (1916).] J. S. Di.

585. *Rainfall with Air Temperature below the Freezing-point.* **S. Takayama.** (Meteorological Soc., Japan, Jan., 1916. Monthly Weather Rev. 44. pp. 514–515, Sept., 1916. Abstract.)—Thirty-six cases of this phenomenon have been picked out from the records of three observatories in Japan. In the large majority of cases air temperature lay between 0 and —2° C. There were three instances with temperature below —5° C. The cases occur mostly in the early morning or at night, rarely in the daytime. In general the phenomenon can be explained by assuming the existence of a temperature inversion, the temperature a little distance above the surface being above the freezing-point. On the other hand, the author has shown from thermodynamical considerations that when condensation takes place continuously in highly supersaturated ascending air both snow crystals and raindrops are formed even though the air temperature is many degrees below the freezing-point, and this may be the explanation of the phenomenon in some cases.

J. S. Di.

586. *Distribution of Precipitation in China during the Typhoons of the Summer of* 1911. **C. C. Chu.** (Monthly Weather Rev. 44. pp. 446–450, Aug., 1916.)—This is a study of the precipitation accompanying each of four typhoons out of the seven which crossed the coast of China in the summer of 1911. Maps are given showing the distribution of rainfall connected with each typhoon, and indicating the track followed by the centre of each disturbance. The typhoon of July 12–21, 1911, was remarkable for the intensity of the accompanying precipitation. For the period July 14–17 at Baguio, Philippine Islands, 2239 mm. (88 in.) of rain was measured, while from noon of July 14 to noon of July 15 the recorded rainfall amounted to 1168 mm. (46 in.) which is said to be the heaviest 24-hour rainfall yet on record for any part of the world. R. C.

587. *Factors influencing the Condensation of Aqueous Vapour in the Atmosphere.* **A. Masini.** (N. Cimento, 12. pp. 110–129, Sept., 1916.)—Experiments on the condensation of water-vapour in the air under different conditions give the following results :—The formation of the nuclei which, besides dust, may provoke the condensation of atmospheric aqueous vapour is determined especially by the presence of ozone, nitrogen peroxide, and, indirectly, ammonia. Electrical discharges, flames (independently of their fumes), and glowing bodies favour condensation in so far as the above substances are formed in their neighbourhood. The property exhibited by some substances of distributing fumes in the air is identified with the phenomenon of deliquescence, the latter property being manifested without the surrounding medium being saturated with moisture. The conception of a medium saturated with vapour is, at any rate in practice, of relative and not absolute character. This relativity is implied by Kelvin's law, according to which the condensation or dew-point depends not only on the vapour pressure, but also on the radius of curvature of the surface of bodies in the immediate neighbourhood of particles of vapour ; it must now be extended to the consideration of the nature of these bodies and of their distance from molecules of the vapour.

Contrary to the conclusions of Lenard and Ramsauer [Abs. 441 (1912)], the action of the ultra-violet light is not necessary for the formation of the nuclei and functions only as a source of ozone. Further, gaseous ions exhibit no power to constitute condensation nuclei, so that ionisation of the air by either radio-active substances or Röntgen rays has not been shown to be a necessary or sufficient cause for the condensation of supersaturated aqueous vapour.

Trees, especially tall ones and those rich in resins, give rise to ozone, and should therefore favour production of rain. Opinions on the actual influence exerted by trees are, however, very variable. T. H. P.

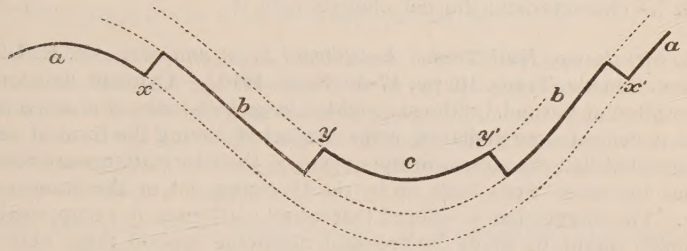
588. *Snow Densities.* **H. F. Alciatore.** (Monthly Weather Rev. 44. pp. 523–527, Sept., 1916.)—The results of over 400 measurements of snow densities made in the Sierra Nevada Mountains are tabulated according to the depth of snow lying. 90 % fall between 0·40 and 0·49 (density = depth of equivalent water divided by depth of snow) and little relationship is found to exist between the mean density of a column and its total depth. After considering the results of other workers in different parts of the world it is concluded : (1) That the average density of a snow cover at or near the close of winter depends primarily on the various atmospheric conditions, particularly as to frosts and rains, under which the several layers have been deposited. It also depends on the age of the snow cover. (2) That the density at different depths does not vary directly as the pressure produced by the superimposed layers as has sometimes been assumed ; and (3) that in a given snow cover strata may occur having abnormally high or low densities. J. S. Di.

589. *Free Air Data at Drexel Aerological Station,* 1915. **W. R. Blair.** (Monthly Weather Rev. Suppt. No. 3. pp. 35–67, 1916.)—The first records were secured on Oct. 22, 1915. After this date kite flights were made as frequently as possible until the end of Nov., 1915. On Dec. 1, 1915, daily flights were commenced, and series of 8 or 10 successive flights have been made whenever practicable. The temperatures obtained by such a series from 10 a.m. on Dec. 21st to 5 p.m. on Dec. 22nd are shown graphically. An inversion of varying intensity existed at 700–800 metres above sea-level, or 300–400 m. above station-level, throughout the period. The mean height reached in the ascents in each of the three months, Oct., Nov., and Dec., 1915, was about 2800 m. above sea-level. In some ascents 5 km. was attained. The mean temperatures at Drexel are compared with those at Mount Weather, Va. Individual results are set out in a table. J. S. Di.

590. *The Horizontal Temperature Gradient and the increase of Wind with Height.* **W. H. Dines.** (Nature, 99. p. 24, March 8, 1917.)—Gives a geometrical proof of the theorem that the condition in which wind velocity continuously increases with height requires that the temperature at any height over the region of high pressure which forms one boundary of the air current should be greater than the temperature at the same height over the corresponding area of low pressure which forms the other boundary of the current.

E. Gold. (Ibid. p. 63, March 22, 1917.)—Gold points out that the converse proposition does not necessarily follow ; that is, if temperature over the high-pressure is not necessarily as high or higher than temperature at the same height over the low-pressure system, then wind does not necessarily increase with height. R. C.

591. *Normal Anomalies of Mean Annual Temperature Variation.* **H. Arctowski.** (Am. J. Sci. 43. pp. 402–409, May, 1917. Phil. Mag. 33. pp. 487–495, June, 1917.)—When mean daily temperatures are plotted to form an annual curve certain discontinuities are often observed. Attention has frequently been called to a sudden fall of temperature which often occurs in the spring, particularly in May or June, but it has not been so generally recognised that similar rises of temperature occur in the autumn. These discontinuities suggest that the mean annual curve is formed of portions of several smooth curves, the transition from one to the next being brought about by a sudden change as shown in the Fig. These component curves



have not necessarily all the same amplitudes, though in some cases they will be similar and the one simply be displaced up or down from the other. It is suggested that these changes from one curve to another may sometimes be due to a sudden change in the amount of atmospheric moisture above the station with a consequent alteration in the strength of the solar radiation received. There is evidence that the steps occur at approximately the same date at such widely separated stations as Baltimore in North America and Barnaoul in Siberia. J. S. Di.

592. *The Variability of Temperature.* **A. Angot.** (Monthly Weather Rev. 44. p. 392, July, 1916.)—Although the meteorological character of a given day depends partly upon that of the preceding days, and perhaps upon those of several previous days, statistics of mean monthly temperature for France show that a similar result does not hold good when the month or the season is taken as time-unit. The variability of monthly, seasonal, or annual temperature in France follows the same law as if the causes were fortuitous, and it is not possible to give forecasts of temperature for months, seasons, or years based upon past observations of temperature. R. C.

593. *Meteorological Observations on Board the "Seneca."* **C. S. Wood.** (Monthly Weather Rev. Suppt. No. 3. pp. 13–28, 1916.)—Kite flights and observations of surface conditions were made from the steamer off the Great Bank of Newfoundland during May and June, 1915. The apparatus and methods of working are described and illustrated. The kite meteorograph used recorded pressure, temperature, and humidity, though the record of the latter proved defective in many ascents. Wireless reports giving surface data for 17 land stations were received each night, and from these with the ship observations pressure charts were plotted which proved of decided value. The upper-air readings are fully set out in tables and temperature-height diagrams are plotted for the 27 successful ascents. These curves may be divided into four types according as the vessel was (A) in the cold Labrador current, (B) in coastal waters, (C) in the warm Gulf Stream, or (D) in mixed waters. Means of all ascents in each group are plotted and

show in the case of (A) and (B) a pronounced temperature inversion of 6° C. up to 300 metres followed by a normal temperature gradient above this level. In (C) there is a normal temperature gradient from the surface upwards, and in (D) almost uniform temperature from the surface to the highest point reached, 1300 metres. The different features of these curves seem to be due to the different temperatures of the surface water in each case. A series of flights made over coastal waters on May 20th show that whereas the temperature of the surface air in contact with the water changed by less than 1° C. between 9 a.m. and 4 p.m. at the 200-metre level a change of 4° C. occurred, due probably to the air having come from over the land and brought its characteristic diurnal change with it. J. S. Dr.

594. *Structure of Hailstones of Exceptional Form and Size.* **F. E. Lloyd.** (Roy. Soc. Canada, Trans. 10. pp. 47–50, Sept., 1916.)—A violent hailstorm of short duration at Carmel, California, yielded large hailstones of unusual shape. Around a central core radiating arms projected having the form of icicles. It is suggested that the stones in the course of their formation were rotating, and thus the arms were built up by the throwing out of the water centrifugally. The suggestion is offered that when hailstones of exceptional type fall moulds might be made by pressing plasticine around them before the ice has time to melt and thus a permanent record of their shape would be obtained. J. S. Dr.

595. *An Eruption of Lassen Peak.* **A. H. Palmer.** (Monthly Weather Rev. 44. pp. 571–573, Oct., 1916.)—Lassen Peak, which, according to Holway, had been quiet for a thousand years, erupted on May 30, 1914, and continued to do so until about 225 eruptions had been recorded. The present cycle of volcanic activity, however, now appears to be almost complete, and while future eruptions will be observed with interest, it is believed that they will be relatively feeble and infrequent. As an active volcano in the United States is such a rare phenomenon, those facts of peculiar interest in meteorology and seismology have been collected in the present paper. Dealing with the matter emitted, the dust and ash consisted entirely of rock fragments, pulverised as by great pressure, and showed no evidence of combustion such as might produce residual cinders. It appears that steam at high temperature accompanied most of the observed eruptions, and this on condensing formed the visible water-vapour which when soiled by the dust particles gave the appearance of smoke. On mixing with the surrounding air this mass cooled, part of the water being precipitated as rain. A considerable amount of sulphur was ejected in the gaseous state. The temperature of the escaping material was estimated at 600° to 900° C. The top of the visible column reached at least 20,000 ft. above the summit of the mountain.

It is concluded that wind is the principal element which determines the distribution of dust and ash resulting from a volcanic eruption. There was no widespread production of a volcanic dust veil, or high haze, such as followed the great eruptions of Krakatoa and Mont Pelée. No effect on the weather was apparent, and there was no evidence of suction or cyclonic effects produced by the drawing in of air laterally to take the place of highly heated air rising vertically. There is no authentic record of a single sensible earthquake occurring in Northern California simultaneously with any of the 225 eruptions. The cause of the present activity of Lassen Peak is now believed to be the immeasurable pressure of expanding lava rising from below, and not the explosive action of steam as in the case of some other volcanoes. Hot

springs and solfataras in the vicinity of the peak show no evidence of increased activity. H. H. Ho.

596. *Earth's Kinetic Energy of Rotation.* **M. Sauger.** (Comptes Rendus, 164. pp. 172–174, Jan. 22, 1917.)—The earth's energy due to rotation is computed on the assumption of a law of density variation $d = d_0(1 - ar^2/R^2)$, with a result much greater than that previously used. The new value is given as 262×10^{26} kilogramme-metres. C. P. B.

597. *Temperature Observations in Loch Earn.* II. **E. M. Wedderburn** and **A. W. Young.** (Roy. Soc. Edinburgh, Trans. 50. pp. 741–767, 1914-15.) —A continuation of the work dealt with in Abs. 362 (1913).

598. *Variation of Latitude,* 1910–1914. **W. M. Worssell.** (Union Obs. of S. Africa, Circ. 36. pp. 279–281, Nov. 1, 1916.)—Continuous observations in connection with the programme of the International Latitude Bureau were made from 1910 March 22 to 1914 Dec. 21. A discussion is given of the corrections applied, and the results for the period, without the linear correction, are plotted in a diagram. C. P. B.

599. *Variations of the Solar Constant.* **H. Arctowski.** (Comptes Rendus, 163. pp. 665–667, Nov. 27, 1916.)—Taking the work of Henry, Langley, and Wilson as indicating that the heat radiations of sun-spots is sensibly less than that from the photosphere, various attempts have been made to detect changes of the solar constant in consonance with the spot period (Savelief, Defaret, Abbot). The present author examines the data from 1905 to 1911, finding no satisfactory agreement in phase of the two phenomena. C. P. B.

600. *Heliographic Positions of Sun-spots and Magnetic Storms.* **H. Arctowski.** (Comptes Rendus, 164. pp. 145–147, Jan. 15, 1917. Soc. Spettroscop. Ital., Mem. 6. pp. 35–36, March, 1917.)—Examining the records of magnetic storms given by Maunder for the period 1882 to 1903, they are tabulated in relation to the positions of sun-spots on different portions of the disc, and a correlation is found suggesting that the radiations producing the storms are deflected from the normal, and are propagated with a velocity differing little from that of light. C. P. B.

601. *Influence of Haze on Solar Spectrum Measurements.* **R. E. De Lury.** (Roy. Astron. Soc. Canada, J. 11. pp. 23–24, Jan., 1917.)—In reply to a former paper by the present author [Abs. 108 (1917)] St. John and Adams have given their reasons for thinking that the influence of atmospheric haze could not be responsible for the differential effects observed in the spectroscopic measurements of the solar rotation. De Lury points out that owing to the negative density being related to the time of exposure by a factor different from unity, there is still a possibility of the haze effect being of importance. Failing this, he suggests that the differential effect may be due to a spectrum of non-rotating matter in the solar atmosphere. C. P. B.

602. *Physical Libration of the Moon.* **P. Puiseux.** (Comptes Rendus, 163. pp. 341–345, Oct. 9, 1916.)—Observations have been made on a number of photographs of the moon taken with the Equatorial Coudé at Paris, with the object of determining accurate details of the libration, and, further, to apply the results to the theory of the moon's physical structure. Details are to be published in the *Annales de l'Observatoire de Paris.* The results are considered as not favouring the idea of the moon being an indeformable solid. C. P. B.

603. *Exponential Law of Planetary Distances.* **E. Belot.** (Comptes Rendus, 163. pp. 564–567, Nov. 13, 1916.)—Some further notes are given on the exponential law of planetary and satellite distances in the solar system. (Ibid. 141. p. 173, 1905.) C. P. B.

604. *Ninth Satellite of Jupiter.* **S. B. Nicholson.** (Nat. Acad. Sci. Proc. 3. pp. 147–149, March, 1917.)—The preliminary orbit derived from observations in 1914 at the time of discovery has been corrected by observations made during the re-discovery at Lick during the 1915 opposition, and this enabled the observers to locate it more easily at Mount Wilson during the recent opposition in 1916. Four images have been found on plates taken by Shapley with the 60-in. reflector, and the orbit is being corrected by means of the collected observations of all three oppositions, the main results being shown in a diagram of the orbits of the eighth and ninth satellites. On account of their great distance from the primary the perturbations produced by the sun are very large for both satellites, and the orbits are not even approximate ellipses. The mean period of the ninth satellite is about 745 days, while the eccentricity appears to be a little less than that of the eighth satellite. The magnitude at mean opposition is estimated at 18·6, which with reasonable assumptions for albedo and colour index would indicate a diameter of about 15 miles. [See Abs. 416, 997 (1915).] C. P. B.

605. *Variability of Uranus.* **E. C. Pickering.** (Harvard Circ. No. 200. Nature, 99. p. 133, April 12, 1917. Abstract.)—Photometric observations made by L. Campbell indicate a variation in the light of the planet Uranus amounting to 0·15 magnitude in a period of 0·451 day, this being nearly the rotation period of the planet as determined spectroscopically by Lowell and Slipher. The variations are ascribed to unequal brightness of different portions of the surface, and, if permanent, may serve to determine the rotation period more accurately than is at present known. C. P. B.

606. *Origin of Retrograde or Direct Orbital Motions.* **E. Belot.** (Comptes Rendus, 163. pp. 297–300, Sept. 25, 1916.)—The difficulties involved in an explanation of the difference of direction of planetary rotations and revolutions on the Laplacian hypotheses have led to various modifications of cosmogonic theories. The author examines the effect of introducing a secondary system of impressed velocities which appears to explain many of the anomalies found in the solar system. C. P. B.

607. *Large-Proper-Motion Stars in Greenwich* 1910 *Catalogue.* **W. G. Thackeray.** (Roy. Astron. Soc., M.N. 77. pp. 204–212, Jan., 1917.)—Tables are given showing the proper motions of the stars in the zone +24° to +32° which have a motion of 20″ or more per century. In the analysis of the statistics it is pointed out that the stars with proper motion ranging between 5″ and 10″ per century are the most symmetrically distributed among all magnitudes; also that out of 2805 stars with proper motions more than 5″ per century, only 77 are brighter than 6·0 mag., so that there are a large number of faint stars whose mean parallactic motion is equivalent to those of the brightest stars, and whose parallax must be sensible. C. P. B.

608. *Distribution of Stars with respect to Galactic Plane.* **F. H. Seares.** (Nat. Acad. Sci., Proc. 3. pp. 217–222, March, 1917.)—An extensive programme of star-counting is being carried out at Mount Wilson, from photographs

taken with the 60-in. reflector, and in this preliminary note the author compares the results of different observers for the distribution of star density in reference to the Milky Way. An important divergence is noted between the factors found by Kapteyn using visual scale magnitudes for the fainter stars, and those by Chapman and Melotte, who employed the Franklin-Adams photographs by photographic intercomparisons with the Harvard Polar Sequence. The Mount Wilson counts are now complete for 88 areas, and include nearly 40,000 stars, with a limiting magnitude adopted as 17·5 (photographic). The provisional conclusion is that the galactic condensation factors are somewhat less than those of Kapteyn, but so much more than those of Chapman and Melotte that it is thought their counts in the richer star-fields fail to include many of the fainter stars. C. P. B.

609. *Statistical Discussion of Stellar Proper Motions.* **F. W. Dyson.** (Roy. Astron. Soc., M.N. 77. pp. 212–218, Jan., 1917.)—The material given by Thackeray [Abs. 607 (1917)] for the proper motions of stars up to and including 9 magnitude on the *Bonn Durchmusterung* scale, included in the Greenwich Catalogue for 1910, is rearranged so as to show the number of stars with proper motions above certain limits out of all the stars down to various limiting magnitudes. A table is given showing the distribution in distance of stars of different magnitudes. C. P. B.

610. *Irregular Variable RS. Camelopardalis.* **H. C. Plummer.** (Roy. Astron. Soc., M.N. 77. pp. 229–231, Jan., 1917.)—A former paper by C. Martin and Plummer having been criticised by H. H. Turner from the point of view of the reality of the conclusions obtained by analysis, the present author insists that the criticism was mistaken. So far from the star being regarded as a slight departure from regularity of the long-period type, the irregularity is so pronounced that any affinity with that class must be considered purely conjectural. C. P. B.

611. *Star with Large Proper Motion.* **F. Gonnessiat.** (Comptes Rendus, 163. pp. 653–654, Nov. 27, 1916.)—Three plates of the zone containing Barnard's large-proper-motion star have been found available for measurement at the Algiers Observatory, taken at the epochs 1897 Aug. 4, 1910 June 15, and 1916 Oct. 7. These on measurement show the motion to be about 10·286″ in position angle 356·07°. The parallax is found to be 1·0″, corresponding to 3·26 light-years. Accepting these values, the linear velocity perpendicular to the line of sight is given as 49 km./sec., and combining this with Adams's value of 91 km./sec. for the radial velocity, the resultant velocity in space becomes 103 km./sec. C. P. B.

612. *Photographic Magnitudes of Stars in Kapteyn's Selected Areas.* **F. H. Seares.** (Nat. Acad. Sci., Proc. 3. pp. 188–191, March, 1917.)—Photographs are being taken with the 60-in. reflector at Mount Wilson to obtain records of the stars in 139 of Kapteyn's selected areas north of latitude −15°. Comparisons with the North Polar Standards will be made to reduce the relative magnitudes to absolute values. The field has an area of about one-ninth of a square degree, and the number of stars shown on the plates with 15 minutes' exposure varies from 40 or 50 in high galactic latitudes to 2000 or 3000 in the star clouds of the Milky Way. C. P. B.

613. *Catalogue and Measures of Double Stars.* **R. Jonckheere.** (R. Astron. Soc., Mem. 61. [205 pp.], 1917.)—Deals with the double stars dis-

covered visually from 1905 to 1916, within 105° of the North Pole and under 5″ separation. The author's earlier work was carried out at Lille (Belgium), and, later, since the war began, with the 28-in. refractor at Greenwich. After an introductory chapter, the distribution of double stars is dealt with, and the conclusion arrived at that "the number of close double stars relatively to single stars depends on the star density in a given region. The greater the number of stars the greater the percentage of double to single stars." L. H. W.

614. *Variable Stars and Nebulæ near R Corona Australis.* **R. Innes.** (Union Obs. of S. Africa, Circ. 36. pp. 282–284, Nov. 1, 1916.)—Details respecting the variability of stars and nebulosity in the neighbourhood of the well-known variable R Corona Australis are described and illustrated by reproductions from photographs taken at the Union Observatory. One of the stars involved in nebulosity has a period of about 26 days, and the minima of the development of the nebulous wisps also show the same period, but the phase is generally opposite to that of the star. C. P. B.

615. *Theory of Rotation of Spiral Nebulæ.* **E. Belot.** (Comptes Rendus 164. pp. 39–41, Jan. 2, 1917.)—The recent results of Van Maanen at Mount Wilson in demonstrating the rotation of the nebulæ M 101 and M 81 appears to confirm the theory of vortices for cosmical systems which has been elaborated by Belot. The exponential equations involved are the same as those he has presented as governing the distances of planets and satellites in our solar system, and the comparison is emphasised as favouring the reality of the theory. C. P. B.

616. *Spectrum of Nebula N.G.C.* 7023. **M. Wolf.** (Astron. Nachr. No. 4875. Nature, 99. pp. 92–93, March 29, 1917. Abstract.)—Many nebulæ in the Milky Way are situated in starless lacunæ, and an examination has been made of their spectra. In the case of H IV 74 Cephei (N.G.C. 7023), the cavity has a diameter of nearly half a degree, and the nebula is found surrounding the star BD + 67° 1283, of magnitude 6·8. This star is of spectrum type A, and the nebula is similar, without any of the characteristics of the gaseous nebula spectrum. This suggests that the nebula shines by reflected light from the star, as has been suggested by Slipher in the case of the Ophiuchus nebula. C. P. B.

617. *Atmospheric Refraction at Mount Hamilton, California.* **W. G. Reed.** (Monthly Weather Rev. 44. pp. 434–436, Aug., 1916.)—In the course of a review of a published set of reduction tables for the Lick Observatory at Mount Hamilton by G. C. Comstock, it is pointed out that the results of refined observations show that the Pulkova tables require correction, and also that there is a diurnal variation in the refraction. This is illustrated by a diagram showing the results based on observations during 1905 and 1906; there is evidence of a sudden fall about two hours after sunset, and again, about two hours before sunrise. C. P. B.

618. *Probable Motions in Spiral Nebula M 51.* **S. Kostinsky.** (Roy. Astron. Soc., M.N. 77. pp. 233–235, Jan., 1917.)—This well-known nebula in Canes Venatici has frequently been investigated by various workers (Rosse Stoney, Copeland, and Mrs. Roberts), with the object of detecting any evidence of motion among the numerous well-marked details of nebulous structure. Continuing the investigation, Kostinsky has since 1896 obtained

at the Russian Observatory of Pulkova 12 plates of the nebula with the large astrographic telescope, the exposures ranging from 47 mins. to 3 hours. Stereoscopic measures have been made on 36 knots shown on two plates taken 1896 March, and 1916 April, and the results indicate proper motions of a systematic character with regard to the centre of the nebula. On the outer spiral the single parts appear to be moving away from the centre, the spiral having a tendency to draw itself together in an anticlockwise direction. On the contrary, on the inner spiral in its eastern part the motion towards the centre prevails, and any tendency to draw together would be clockwise. The annual proper motions of the single knots vary within wide limits ; in the mean they are of the order of 0·04″ to 0·05″. C. P. B.

619. *Extinction of Light in Space.* **J. Halm.** (Roy. Astron. Soc., M.N. 77. pp. 243–280, Jan., 1917.)—Details are given of the standardisation of the C.P.D. catalogues, which are found to be in substantial agreement with Mount Wilson results. The results are analysed in the relation of magnitude to star density, distance, and proper motion, with conclusions in favour of the existence of some type of extinction of light in space. C. P. B.

620. *Aurora Borealis Observations at Bossekop in* 1913. **C. Störmer.** (Terrest. Magn. 21. pp. 153–156, Dec., 1916.)—Preliminary reports have already been published on the results of the expedition [see Abs. 1236 (1915), 315 and 1118 (1916)]. The present communication describes the results obtained on the last two nights, March 30 and April 1. The height and position of the auroræ were determined by means of simultaneous photographs taken at the ends of a base line 27·5 km. in length lying in a north-south direction. A diagram is given showing the distribution in height of these auroræ and two pairs of photographs of the curtain are reproduced. During the night of April 1 points along an auroral ray were measured, and it was found that the ray extended from 245 km. down to 153 km. above the earth's surface. As the base of the auroral curtains usually lies at about 100 km. height the corpuscular rays producing this auroral ray must have had very slight penetrating power. J. S. Di.

621. *Inferences concerning Auroræ.* **E[lihu] Thomson.** (Nat. Acad. Sci., Proc. 3. pp. 1–7, Jan., 1917.)—The author contends that the streamers seen in auroræ, singly or in composite masses, are in reality vertical, and that their convergence towards the zenith which is noticed in the greater auroræ is purely a perspective effect. These vertical rays in general spring from a definite layer about 50 miles above the earth's surface. It is suggested that this is a conducting layer and the rays indicate a flow of electrons outward from it along vertical paths. In the case where the streamers are confined to a narrow belt in latitude and are seen from some point to the south of this belt their lower ends will constitute the so-called auroral arch. The curvature of this arch is an optical effect of perspective slightly added to by the curvature of the earth. If the above theory is correct, some auroral streamers must be hundreds, or even a thousand or more, miles long. The author has held the view here set forth as to the nature of auroral streamers for many years, and has found it to be strengthened by the study of successive auroræ. J. S. Di.

LIGHT.

622. *New Zenith Telescope.* **G. Bigourdan.** (Comptes Rendus, 164. pp. 18–21, Jan. 2, 1917.)—Most of the instruments in present use for zenith measurements depend in some way or another on a telescope adjusted on the nadir by means of reflection, or by a level, or by a plumb-line, and in general the telescope is liable to flexure or change of collimation during the movement from one position to another. A form of instrument is designed to avoid these disadvantages, consisting of two telescopes rigidly connected, parallel to each other, one with objective pointing to the zenith, the other towards the nadir. The whole is mounted so as to permit of rotation through 18° about a vertical axis, so that no change with respect to gravitation is involved. C. P. B.

623. *Polarisation Flicker Photometer.* **H. E. Ives.** (Phil. Mag. 33. pp. 360–380, April, 1917.)—In previous papers [Abs. 299 (1915), 320 (1916)] the author emphasised the desirability of arranging for the transition from one field to another in a flicker photometer to follow a simple mathematical relation. He now describes a polarisation flicker photometer satisfying this condition. By the rotation of a nicol the images of the respective photometric surfaces, polarised respectively in vertical and horizontal planes, can be made to fade gradually into each other, each image being alternately extinguished. The transition then follows the cosine law exactly, and this enables the relations between intensity and critical speed to be verified in an exact quantitative manner. The relations established by the author illustrate the necessity for a speed such that discrimination of hue is lost but discrimination of brightness still persists. This is shown by appropriate diagrams. J. S. D.

624. *Differential Refractometer for measuring the Salinity of Sea-water.* **A. Berget.** (Comptes Rendus, 164. pp. 400–402, March 5, 1917.)—Measurements of the index of refraction can be used to determine the salinity of sea-water. In the method here given, monochromatic light from a collimator falls normally on one face of a rectangular glass vessel which is divided into two parts by a glass plate along one diagonal. Two prisms are thus obtained, and if they contain liquids of the same index the ray traverses the system with no deviation. If the two liquids have indices of refraction n and n', and the angle of the prisms is A, the deviation $\Delta = (n - n')A$. In order to measure this deviation the emergent beam is allowed to fall on a lens which gives a real image of the collimator slit. This image is then examined through a microscope provided with a micrometer eyepiece. The refractive index of a sample of sea-water is thus determined in terms of that of a standard sample. The method is very rapid, and has the advantage of requiring only a few cm.^{3} of liquid. In addition, it is susceptible of considerable accuracy. A. W.

625. *Diffraction Colour Box.* **A. W. Clayden.** (Phys. Soc., Proc. 29. pp. 176–181; Disc., 181–182, April, 1917.)—The apparatus consists essentially of a very simple concave grating spectroscope, of which the slit and grating are situated at opposite diameters of a circle, the spectrum being formed in the arc of this circle. Two independent arms carry fittings on

which may be placed either telescope eyepieces or small electric lamps. With the slit of the instrument illuminated by a suitable source, the eyepieces can be set so that two desired wave-lengths are in the centres of their respective fields of view. The eyepieces are then replaced by the small lamps, and the grating is observed with a small telescope pointed towards the widened slit; the whole of its surface is seen to be illuminated with a mixture of the two colours in which the eyepieces were originally set. The concave grating consists of a Thorpe replica of a Rowland plane grating of 14,475 lines to the inch, mounted with its ruled surface in contact with that of a concave mirror of 4 ft. focal length. Observations showed that the smallest change of wave-length which could be recognised by the eye as a change of colour was greater than that of one vibration more or less in 10^{-12} sec. E. H. B.

626. *New Method for determining the Refractive Index of a Liquid.* **A. Ledoux.** (Comptes Rendus, 164. pp. 305–308, Feb. 12, 1917.)—The author previously described a method of measuring the principal refractive indices of a doubly refracting solid by observing the retardation caused by a thin lamina placed obliquely between crossed nicols [Bull. Soc. franç. Minéralogie, Dec., 1916]. He now suggests how that method may be applied to find the index of a liquid. A lamina, cut parallel to the axis, of a uniaxial crystal of which the principal indices are known, is immersed in the liquid of which the index is to be found, the axis lying in the plane of incident light. Let r_1 be the measured retardation due to the lamina in the liquid, r_2 the retardation for normal rays, N the index of the liquid, and n the index of the crystal (the smaller index for a positive crystal, or the larger index for a negative crystal), then $N = n\sqrt{(1 - r_1^2/r_2^2)}/\sin I$. The principal indices of quartz for the D line, according to de Lépinay, are 1·55336 and 1·54425. For a quartz lamina of thickness 0·10 mm. cut parallel to the axis, $r_2 = 911 \times 10^{-6}$ mm. If the lamina be inclined so as to give the first sensible indication of the violet, $r_2 = 575 \times 10^{-6}$. Substituting these values, we have $N = 1{\cdot}197783/\sin I$. The author tabulates values of N corresponding to every degree of I from 35° to 80°, for D light at 15° C. A few of the figures are quoted below. If the required index N be greater than 1·55, the lamina may be inclined till the field becomes dark, in which case $r_2 = 0$, and $N' = 1{\cdot}54425/\sin I$.

I	N	N′	I	N
80°	1·2163	1·5681	45°	1·6939
70°	1·2747	1·6434	40°	1·8634
60°	1·3831	1·7832	35°	2·0883
50°	1·5636	2·0159		

In making the measures the liquid is placed in a small vessel on the stage of a microscope, between crossed nicols. The quartz lamina is fixed to a small rod which passes through the wall of the vessel, and can be turned freely, the angle of rotation being measured by means of a pointer carried by the rod. To start with, the quartz lamina is brought to the horizontal position, and the microscope stage is turned to obtain extinction between crossed nicols. The stage is then turned through 45°, and the quartz lamina inclined until the first violet (or darkness if preferred) is obtained. A. E.

627. *Fundamental Scale of Pure Hue, and Retinal Sensibility to Hue Differences.* **L. A. Jones.** (Optical Soc. of America, J. Jan., 1917. Frank. Inst., J. 183. pp. 500–508, April, 1917. Abs. of Comm. No. 44 of Research Lab. of the

Eastman Kodak Co.)—The first step in the establishment of the fundamental hue scale is the determination of precise values (in terms of wave-length units) for the average normal human eye of the least perceptible hue differences (the sensation unit) throughout the visible spectrum. The final values must be the result of the proper summarisation of a large number of data obtained from the study of many individuals having normal vision. Steindler has made measurements on the hue sensibility of 12 subjects, all having normal colour-vision. As further data seemed desirable, a number of other results have been obtained with apparatus designed to give very pure monochromatic light of easily measurable and variable wave-length, in connection with some type of two-part photometer field, each part of which may be illuminated independently by monochromatic light of variable quality and intensity. For this purpose a Brace spectrophotometer was used with a Hilger spectroscope of the constant-deviation type. The curves obtained with this apparatus agree fairly well with those of Steindler except in the blue between 400 $\mu\mu$ and 470 $\mu\mu$. The results also show that an observer can repeat results on hue difference fairly well, and that the difference-wavelength curve for an individual has a very definite shape. From this curve it is easy to determine whether any series of hues are separated by equal or unequal sensation steps. This method has been applied to the Ridgway system of colour standards, and the results are tabulated. Many more data are still needed for the establishment of the hue sensibility curve of the average normal eye. A. W.

628. *Studies of the Ultra-violet Transparency of Certain Coloured Media.* **H. W. L. Absalom.** (Phil. Mag. 33. pp. 450–455, May, 1917.)—An examination of the ultra-violet transparency of a large number of gems and minerals, some of which are artificially coloured by kathode-ray bombardment, and solutions of metals in liquid ammonia.

The limits of transparency are given and the results are discussed from the standpoint of colloidal colouration. C. S. G.

629. *Colours of Mother-of-Pearl.* **A. H. Pfund.** (Frank. Inst., J. 183. pp. 453–464, April, 1917.)—The investigation described was undertaken to ascertain the cause of the iridescence of mother-of-pearl. Quantitative measurements are presented which substantiate the original conclusions of Brewster. These results were possible in consequence of extending the observations into the infra-red region of the spectrum, where the conditions are much simplified.

It appears that mother-of-pearl owes its colours to two causes : (*a*) diffraction of light due to a grating-like structure of the terminal edges of successive laminæ, (*b*) interference of light due to reflection from numerous parallel laminæ of sensibly equal thickness. By means of celluloid "replicas" the study of diffraction colours was carried out. Interference measurements in the infra-red region then gave data from which it was found that the thickness of the laminæ for many different samples lies between the limits 0·4 μ and 0·6 μ. A. W.

630. *"Colour Temperature" of Illuminants.* **E. P. Hyde** and **W. E. Forsythe.** (Frank. Inst., J. 183. pp. 353–354, March, 1917.)—It has been found that the light from most ordinary illuminants can be matched in colour by the light from a black body operating at some particular temperature, which is called the "colour temperature" of the source in question [see Abs. 706 (1915)]. In the case of candles, oil lamps, ordinary gas flames, and electric glow-lamps, it is found that when operating at a colour match

the distribution of energy in the visible spectrum of the black body and the source is quite closely the same, although this would not necessarily follow. Data have been obtained on the colour temperatures of various illuminants, and it is suggested that these be made the basis of a colour scale for sources whose light is sufficiently near that of a black body to permit of comparison. For sources such as the Welsbach mantle, whose light cannot be matched in colour with that from a black body at any temperature, special treatment is necessary. The colour temperatures of some of the most common illuminants are as follow :—

Source.	Colour Temperature (°K.).
Gas flame, fish-tail burner	1870
Hefner	1875
Pentane (10-candle standard)	1914
Paraffin candle	1920
Kerosene lamp (round wick)	1915
Acetylene flame	2368
4·0-w.p.h.c. carbon lamp	2070
1·25-w.p.h.c. tungsten lamp	2385
0·5-w.p.h.c. gas-filled lamp	(2900)

J. W. T. W.

631. *The Visibility, above the Temperature of Isotropic Fusion, of Regions of Contact between Anisotropic Liquids and Crystals.* **F. Grandjean.** (Comptes Rendus, 164. pp. 431–434, March 12, 1917.)—An anisotropic liquid contained between two slips of glass shows doubly-refracting regions which possess the peculiar property that if they are caused to disappear by isotropic fusion they reappear in the same place on cooling to the original temperature, and with the same orientation and outline. They behave, in fact, like a pattern which is rendered invisible but is left unaltered by fusion. To explain this behaviour, we can imagine that the molecules retain their orientation in contact with the solid body, in spite of isotropic fusion, or that they recover their orientation because at each point of contact the solid imposes on the liquid a perfectly definite orientation. The author finds that, even above the temperature of isotropic fusion, the regions leave visible traces, which the author calls pellicules, between crossed nicols, and the author describes the manner of observing these pellicules, which are doubly refracting and have the same orientation as the regions. The facts obtained are in agreement with the theory put forward by the author in a previous communication [Ibid. pp. 280–283, Feb. 5, 1917]. A. F.

632. *Black Photographic Images produced by Kathode Rays.* **M. Wolfke.** (Phys. Zeits. 18. pp. 128–130, March 15, 1917.)—It is well known that kathode rays can produce two entirely different effects when they fall on a photographic plate. For short exposures the part of the plate on which the rays fall is blackened : for lengthy exposures a kind of "solarisation" (see T. Retschinsky, Jahrb. d. Radioakt. 13. p. 75, 1916), or photographic reversal, is obtained. The author considered that in obtaining photographic records of deflections of kathode rays (*i.e.* parabolic paths on the plate) short exposures would result in sharper and blacker photographs. Experiments have been made to determine the best conditions for obtaining such clear photographs, with the following results :—(1) There must be a direct connection between one of the two electrodes (deflecting the rays) and the case of the camera ; (2) the pressure must be the lowest possible, not only in the camera but also in the discharge-chamber itself ; (3) a high discharge voltage is essential.

A. B. W.

633. *Contradictions involved in Wave-kinematics and their Solution.* H. **K. Uller.** (Phys. Zeits. 18. pp. 130–132, March 15, 1917.)—When a wave is evolved on the interference principle certain aspects of the Huyghens-Kirchhoff theory are inadmissible. According to the latter theory the wave, beyond its source, may be regarded as originating at any point by the mutual interference of elementary spherical waves proceeding from every element of a surface surrounding this origin. Every point of the wave is thus regarded as the starting-place of spherical waves. In the present paper the author discusses mathematically the true significance of the above important surface hypothesis. Waves of elementary vibration type are first considered. The Huyghens-Kirchhoff procedure and its generalisation depends on the assumption of a superposed subsidiary wave in order to refer the origin to any desired point, and the author, after pointing out the limitations to this hypothesis, considers at some length other surface theories which are independent of the superposition of a subsidiary wave. [See also Abs. 458 and 459 (1917).]

H. H. Ho.

634. *Entrainment of Luminous Waves and Solar Phenomena.* **P. Zeeman.** (Comptes Rendus, 163. pp. 269–271, Sept. 11, 1916.)—By recent experiments the author has verified the expression $\varepsilon = 1 - 1/\mu^2 - \lambda/\mu \,.\, d\mu/d\lambda$ for the coefficient of entrainment. This is the expression of Fresnel, completed by the complementary term, $-\lambda/\mu \,.\, d\mu/d\lambda$, due to Lorentz. In the present note the author shows that the presence of this complementary term involves a change in the propagation of waves in a medium, in other respects homogeneous but whose velocity is not everywhere the same.

This idea is worked out numerically for water, CS_2, and sodium vapour. It is pointed out that even in a homogeneous metallic vapour the simultaneous existence of dispersion and of differences of velocity should curve the rays which traverse the medium. [See Abs. 1340 (1916).] E. H. B.

635. *The Rotatory Power of Crystalline Liquids.* **P. Gaubert.** (Comptes Rendus, 164. pp. 405–406, March 5, 1917.)—The author has examined the rotatory power of crystalline liquids by a new method, and finds that the rotatory power which at first is feeble while the substance reflects the violet light, increases as the temperature falls, or rather as the colour reflected has a greater and greater wave-length. With pure cholesterine propionate it exceeds 1000° for the yellow rays and for a thickness of 1 mm. For each kind of ray, excepting the violet rays which have not been examined, the substance is at first lævo-rotatory and then dextro-rotatory. This change in the sign of rotation is not simultaneous for all colours; it takes place in each case at the moment when the preparation reflects that light. At this point one of the two circular rays is absorbed, and there is consequently no rotatory power for that colour; but when the colour passes towards the red, the rotatory power reappears, with opposite sign, and goes on increasing. Accordingly, if a preparation reflects yellow light, the substance is dextro-rotatory for green and blue, and lævo-rotatory for red. A. F.

636. *Natural and Magnetic Rotatory Dispersion in the Infra-red Spectrum.* **L. R. Ingersoll.** (Phys. Rev. 9. pp. 257–268, April, 1917.)—The author has determined the natural and magnetic rotatory dispersions of quartz, limonene, pinene, and solutions of cane sugar, tartaric acid, and camphor over a range of wave-length from the visible to beyond 2 μ. The curves are all regular save in the case of tartaric acid in the shorter wave-lengths. The natural rotation for quartz over the whole spectral range agrees very well with the

formula used by Lowry, with constants determined by him from visible spectrum observations. The temperature coefficients of rotation as determined for quartz and limonene show no definite dependence on wave-length. The natural and magnetic rotation coefficients have quite different values, however, in the case of limonene. Wiedemann's law of the proportionality of natural and magnetic rotations holds with a fair degree of approximation for quartz and the two terpenes over the whole spectral range investigated. It does not hold as well for the solutions, the variation being greatest in the case of camphor. A. F.

637. *Line and Band Spectra.* **J. Stark.** (Ann. d. Physik, 52. 3. pp. 221–254, April 3, 1917.)—A continuation of previous work [Abs. 677 (1916)]. The present paper deals more particularly with the spectrum given by the positively-charged H_2-molecule ions. Discussion of results obtained by the author and others leads to the conclusion that the neutral H atom gives no spectrum in the visible region. It also appears that the band spectrum of hydrogen cannot be due to the neutral H-atom carriers, but to the positively-charged H_2-molecule ions. Further work showed that the H_2O ion gives no lines of appreciable intensity in the visible spectrum. It appears probable that the neutral H atom is responsible for the many-lined band spectrum beyond $\lambda 1850$, observed by Schumann in the condensed spark in hydrogen. When the positively-charged H_2 ion is coupled with an electron, a continuous spectrum is given extending from the blue-green into the ultra-violet. This appears most intense at the commencement of the positive layer, especially the blue part. The coupling of the positive H ion with an electron gives rise to a continuous spectrum in the ultra-violet, the greatest intensity being in the neighbourhood of 250 $\mu\mu$. This continuous spectrum is seen best in the canal-ray hydrogren spectrum. A. W.

638. *Continuous Spectrum due to the Coupling of an Electron with a Positive Ion.* **J. Stark.** (Ann. d. Physik, 52. 3. pp. 255–275, April 3, 1917.)—A continuous spectrum of hydrogen in the ultra-violet has been observed by several investigators [Abs. 1096 (1906), 1244 (1909)]. Stark now shows that hydrogen gives two continuous spectra, one in the ultra-violet about 250 $\mu\mu$, and one in the blue-violet. Further, he shows that the vapours of Cd, Hg, of the alkalies Li, Na, K, Rb, Co, and of the alkaline earths, also give continuous spectra. In each case the continuous spectrum is shown to be due to the coupling of a positive ion with an electron. A. W.

639. *Phosphorescence of the Uranyl Salts.* **E. L. Nichols** and **H. L. Howes.** (Phys. Rev. 9. pp. 292–304, April, 1917.)—All uranyl salts thus far examined possess the same type of phosphorescence; *i.e.* with increasing instead of diminishing rates of decay. This is true not only of the crystalline forms, but also of uranyl compounds in solid solution or in the plastic state characteristic of the double phosphates. The initial brightness of phosphorescence under like excitation varies greatly with the different salts, as does also to some extent the rate of decay. The brightness of a salt newly prepared in darkness is greater when first excited than subsequently, but it soon reaches a nearly stable condition. Exposure to red and infra-red rays is without effect as regards the rate of decay. The phosphorescence, like the fluorescence of the uranyl salts, appears to be independent of the mode of excitation, and the structure of the intricate spectrum is the same during excitation and through the observable phosphorescent interval. Changes in the rate of decay are not continuous, but occur in definite steps, there being

at least three successive processes within the interval covered by observations, about 0·006 sec. These processes follow a law such that $I^{-1/2}$ is in linear relation to the time. The first and second processes, counting from the close of excitation, are of nearly equal duration, increasing in duration with the intensity of excitation in such a manner that the duration of the process is approximately proportional to the natural logarithm of the excitation. In certain salts, such as uranyl ammonium nitrate, decay is retarded by cooling ; in other cases the temperature effect is slight. Uranyl nitrates with 2, 3, and 6 molecules of water of crystallisation vary greatly in the rate of decay, but the changes in crystalline form appear to be more important in this respect than the amount of water. In the case of the polarised spectra of the double chlorides, both components decay at the same rate, and no change of relative brightness could be detected throughout the range covered by observation. [See Abs. 1349 (1916).] A. W.

640. *Theory of the "Integral Iontometer."* **T. Christen.** (Phys. Zeits. 18. pp. 165–167, April 15, 1917.)—In an earlier paper [see Abs. 1673 (1915)] the author described a method for the measurement of the energy of ionising radiation independent of its penetrating power. This instrument has previously been referred to under the title of "Integral Iontometer." The apparatus contains an ionisation-chamber into which an absorbing body of such a shape can be introduced, that the more easily absorbed rays are cut down in exactly the same ratio, as in the case where air alone is used as the absorbing medium. In that paper it was stated that the ratio of the absorption coefficients (α for the absorbing body, and β for air) is expressed by the relation $\beta/\alpha = c$, where c is a constant which is independent of the hardness of the X-rays. Subsequent experience has shown that this relation is incorrect, the ratio β/α not remaining constant as the hardness of the radiation increases. The error introduced by assuming β/α constant is calculated for different values of hardness, and the required change of shape of the absorbing body determined. The longitudinal cross-section of the body is approximately a parabola (of air) cut out of a rectangle (of aluminium). A. B. W.

641. *Radiation and Atomic Structure.* **R. A. Millikan.** (Science, 45. pp. 321–330, April 6, 1917. Presidential Address to the Am. Physical Soc., Dec., 1916.)—An outline of recently published work on this subject. Particular stress is laid on the importance of Moseley's work on X-rays and atomic numbers, and of Bohr's theoretical papers on spectra and atomic structure.

A brief abstract cannot be given. A. B. W.

642. *Structure of the Ultra-violet Mercury Lines.* **N. Galli** and **K. Försterling.** (Phys. Zeits. 18. pp. 155–158, April 15, 1917.)—Describes measurements on the structure of the ultra-violet mercury lines made with a Lummer-Gehrcke plate used in conjunction with a large Fuess spectrograph. The results are compared with those obtained previously by Janicki, v. Bayer and by Tamine. A. W.

RADIO-ACTIVITY.

643. *Initial Charged Condition of the Active Deposits of Radium, Thorium and Actinium.* **G. H. Henderson.** (Roy. Soc., Canada, Trans. 10. pp. 151–167, March, 1917.)—The paper commences with a *résumé* of previous work on this subject. The researches of the following are touched upon :—

Rutherford, Russ, Kennedy, Wellisch and Bronson, Schmidt, Eckmann, Walmsley, Lucian. The results of these authors differed so widely that it was not clearly established whether any definite fraction of the rest-atoms of Ra, Th, or Act was initially uncharged, or if partly charged what the value of this fraction was. In many of the experiments made by the above physicists a considerable source of error is probably to be found in the faulty design of the testing vessel. The author enumerates the conditions essential to an "ideal" testing vessel. The cylindrical type of vessel used by many investigators does not fulfil these conditions satisfactorily. The author describes in detail a parallel-plate type of vessel which satisfies all the important conditions of the "ideal" instrument. His results are summarised as follows:—"All the available data indicate that the rest-atoms of Ra, Th, and Act are affected similarly by the surrounding gas and behave similarly in electric fields. The slight differences which do exist, are differences of degree and not of kind. The rest-atoms were found to be initially all charged alike, either all positive or all neutral, when surrounded by molecules of a single kind. In air, hydrogen, oxygen, CO_2, etc., the rest-atoms are initially all positively charged. In ether, water-vapour, ethyl bromide, etc., the rest-atoms are initially all neutral. In atmospheres containing molecules of both types, the fraction of the rest-atoms positively charged depends on the relative numbers of the two kinds of gas molecules present. The recombination between rest-atoms and ions has been shown to consist of three distinct types: 'volume,' 'columnar,' and 'initial.' It has been pointed out that not only the volume and columnar recombination, but also initial recombination, should take place between ions themselves. A possible explanation of what takes place during recoil has been advanced to account for the initial charged conditions of the rest-atoms in atmospheres composed of a single gas and of a mixture of two gases.

A. B. W.

644. *Comparison of Radium Standard Solutions.* **J. Moran.** (Roy. Soc. Canada, Trans. 10. pp. 77–84, Dec., 1916.)—The object of the experiments described was to redetermine the values of the Rutherford-Boltwood weak and strong solution standards. They were prepared in the first place by means of the Rutherford-Boltwood solid standard—now at Manchester University—and this solid standard was found by Rutherford to be 4·9 % low.

The present work proves that errors had been introduced previously by using HCl containing a small amount of radio-active matter. Important refinements in the apparatus have now been introduced. A. B. W.

645. *Release of Radium Emanation from Water at Different Temperatures.* **J. Moran.** (Roy. Soc. Canada, Trans. 10. pp. 57–64, Sept., 1916.)—This paper describes a study of the release of radium emanation from water by bubbling air through the radium solution at different temperatures, at a definite rate of flow of air. Observations were made with the temperatures of the solution at 16·5°, 20°, 30°, 60°, and 80° C., and the results show that the release of emanation is considerably increased as the temperature rises, naturally reaching an upper limit at 100° C.

It is proved that temperature is an important factor in the determination of RaEm by the bubbling method, and should be known and kept constant during an experiment. A. B. W.

HEAT.

646. *A Calorimetric Resistance Thermometer.* **S. L. Brown.** (Phys. Rev. 9. pp. 205–209, March, 1917.)—Description of a resistance thermometer utilising the temperature coefficient of resistance of metallic oxides. The thermometer is constructed by thrusting two wires into a globule of the molten oxide, such as lead oxide, and allowing it to cool so that only a thin layer of the solid oxide separates the wires. The resistance may range from a few hundred ohms to several thousand ohms.

The experiments described, using a lead-oxide thermometer, show that it possesses the features of permanency and of reproducibility when subjected to the temperature range from —10° to 120° C. The advantages claimed for this type are: (1) No compensating leads necessary; (2) low heat capacity; (3) absence of thermal e.m.f.'s owing to the proximity of the junctions; (4) great sensitivity: temperature measurements can be reproduced to within a few thousandths of a degree.

The principal disadvantage, as compared with a Pt-resistance thermometer, is that there is no simple relation between resistance and temperature. The calibrations must be a point-by-point comparison with a standard. [See also Abs. 753 (1915.] E. G.

647. *Supposed Fusion of Carbon by O. Lummer.* **M. La Rosa.** (N. Cimento, 12. pp. 97–109, Sept., 1916.)—The author challenges Lummer's statement ("Verflüssigung der Kohle, etc.," Braunschweig, July, 1914) concerning the liquefaction of carbon in the crater of the arc. The author's own success in obtaining carbon in the liquid condition is shown by the presence of spots of graphite which have spurted on to the porcelain dish used in the experiments with the Joule-effect. The central part of each spot is composed of minute, shining laminæ of graphite, quite unlike the ordinary deposits of carbon obtained by sublimation. Unless great care is taken in the purification of the carbon rods, these spots are not obtained, the impurities scattered throughout the carbon forming fusible compounds and the rod acquiring here and there pronounced pastiness at a comparatively low temperature; the rod thus breaks before the temperature reaches the value necessary to render the mass quite liquid. T. H. P.

648. *Ring Ice in Refrigerator Sprinkler Pipes.* **H. T. Barnes.** (Roy. Soc. Canada, Trans. 10. pp. 93–96, Dec., 1916.)—In the dry-pipe sprinkler system of fire protection for cold-storage rooms the water of the sprinkler piping is replaced by compressed air at about 40 lbs. pressure. For long periods no water enters the dry pipes, and consequently no accumulation of water can take place at any point unless supplied to the system from without. It has frequently been found, however, that ice appears inside the pipes and grows on the parts exposed to the coldest temperature. This ice forms as hoar-frost and encircles the inside of the pipe, gradually closing in until only a small hole is left through the interior. The author discusses the probable source of the water giving rise to the formation of this "ring" ice, and gives a table showing the amount of water required, when converted into ring ice, to fill one foot-length of various-sized pipes. The paper is illustrated by two photographs showing the formation of ring ice.

J. W. T. W.

649. *Effect of Stretching on Thermal Conductivity of Wires.* **A. Johnstone.** (Phys. Soc., Proc. 29. pp. 195–202 ; Disc., 202, April, 1917.)—In the experiments carried out, the wire to be tested was fixed at each end between jaws joined to brass cylinders, through which water could be circulated. Attached to one clamp was a rod passing through a framework, enabling tension to be applied. Heat was supplied through a manganin coil wound on the wire, and the temperature difference between two points on the same side of the centre was ascertained by two Pt coils, also wound on the wire. The resistances of the coils were determined by means of a Callendar-Griffiths bridge reading to 0·01 deg. C. and detecting a difference in conductivity of 0·05 %.

For all wires used (Cu, steel, Ni, Al, brass, Zn), stretching produced a slight increase in thermal conductivity. The best experiments showed an increase of about 0·5 % for a tension of about 0·7 of the elastic limit.

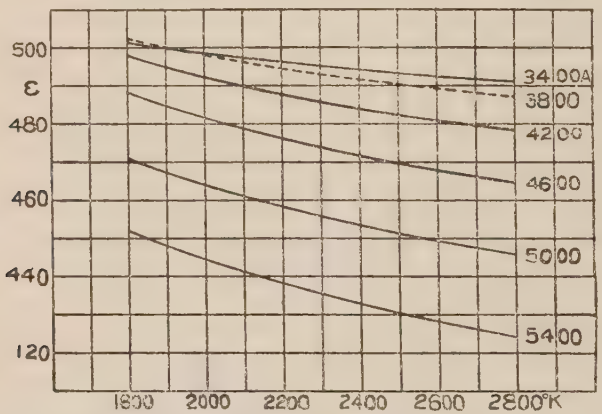
After the tension was withdrawn the conductivity returned nearly to its original value. E. H. B.

650. *Effect of Stretching on Thermal and Electrical Conductivities of Wires.* **C. H. Lees.** (Phys. Soc., Proc. 29. pp. 203–205, April, 1917.)—Reviews the results obtained for Cu, Zn, Al, Ni, Fe, steel, and brass, by Smith, by Tomlinson and by Johnstone as to these conductivities, from which the following conclusions are drawn :—If we except the change of the electrical conductivity of the hard Ni used by Tomlinson, which was probably far from pure, the results so far available appear to justify the statement that when the commoner metals and alloys are subjected to a tension not exceeding the elastic limit for the material, the thermal conductivity in the direction of the tension is *increased* at a ratio between (4 and 10) $\times 10^{-6}$ of itself per megadyne per cm.^{2} of section, while the electrical conductivity is *decreased* under the same circumstances at about one-tenth of the above rate. The quotient of the thermal by the electrical conductivity increases at a rate between (4 and 11) $\times 10^{-6}$ of itself per megadyne of stretching force per cm.^{2}. [See Abs. 748 (1912) and preceding Abs.] E. H. B.

651. *Condensation and Evaporation of Gas Molecules.* **I. Langmuir.** (Nat. Acad. Sci., Proc. 3. pp. 141–147, March, 1917.)—Previous work by the author [see Abs. 891 (1913)] gave evidence that atoms of tungsten, molybdenum, or platinum vapours, striking a clean, dry glass surface in high vacuum, are condensed as solids at the first collision with the surface. Similar evidence was obtained from a study of chemical reactions in gases at low pressures. It was concluded that in general, when gas molecules strike a surface, the majority of them do not rebound from the surface by elastic collisions, but are held by cohesive forces until they evaporate from the surface. In this way a theory of adsorption was developed which has been thoroughly confirmed by later experiments, viz., the amount of material adsorbed depends on a kinetic equilibrium between the rate of condensation and the rate of evaporation from the surface. Practically every molecule striking the surface condenses (independently of the temperature), while the rate of evaporation depends on the temperature and is proportional to the fraction of the surface covered by the adsorbed material. R. W. Wood's experiments on mercury atoms impinging on a glass plate at definite temperatures are referred to and discussed, following which comes a review of Wood's experiments on a stream of cadmium atoms, which stream, on striking walls of a well-exhausted glass bulb does not form a visible deposit unless the the glass is at a temperature below about —90° C., but when started the deposit

continues to grow in thickness even after it is warmed to room temperature. Wood concludes that nearly all atoms of cadmium are reflected from surfaces other than cadmium if the initial temperature is above —90° C. The present author criticises this reflection theory and proposes as a better alternative the condensation-evaporation theory, and, to determine definitely which of the two theories correspond best with the facts, he has repeated Wood's experiments under modified conditions which are described at some length. The experiments prove that single cadmium atoms actually evaporate off of a glass surface at temperatures below room temperature, although they do not do so at an appreciable rate from a cadmium surface. The condensation-evaporation theory thus verified affords a very satisfactory explanation of Moser's breath-figures on glass and the peculiar effect observed in the formation of frost crystals on window-panes. The author opines his theory to be capable of extension to the whole subject of nucleus formations, including the crystallisation of supercooled liquids. H. H. Ho.

652. *Emissive Power of Tungsten for Short Wave-lengths.* **E. O. Hulburt.** (Astrophys. J. 45. pp. 149–163, April, 1917.)—Describes an investigation of the changes in the emissive power of tungsten throughout the region of the spectrum from 3400 Å. to 5400 Å. for true temperatures from 1746° to 2785° K.



A sodium photoelectric cell with an electrometer was employed for the measurement, and preliminary investigation (described in the paper) showed that the energy/deflection curve was linear for this cell. A full account is given of the various corrections made to the results obtained. These include corrections for (i) the variation with wave-length of the transmission coefficient of the glass bulb containing the tungsten strip under experiment, (ii) the light scattered by the grating, (iii) the slit width. The values obtained for the emissive power at each wave-length for different temperatures are shown in the Fig. J. W. T. W.

653. *Maxwell's Equations and Atomic Radiation.* **T. Wereide.** (Ann. d. Physik, 52. 3. pp. 276–282, April 3, 1917.)—In recent work on radiation and the constitution of atoms, problems dealing with the validity of the electrodynamic laws have more than ever come to the front. It is to be expected that as these laws are applied to systems of ever smaller dimensions divergences will present themselves sooner or later, in accordance with the fact that every physical law has been framed to explain experience within

defined limits. Now, Maxwell's electrodynamic laws were derived from data obtained from systems of fairly large dimensions, and so when atomic systems are considered large discrepancies are to be regarded as normal, and transition stages expected to occur. The actual facts, however, appear to be otherwise. By the application of electrodynamic formulæ to systems of atomic dimensions, either very good agreement is obtained or the theoretical demands are in complete contradiction with the facts—*e.g.* while the electrodynamic equations entirely explain the Zeeman-effect and have even predicted its existence, yet Bohr's electronic orbits are found to be impossible although regarded by many physicists as established.

In an earlier publication the author has shown that the supposed contradiction between Planck's formula for dark radiation and the electrodynamic laws does not exist, while the object of the present paper is to prove that with atomic radiation there is also no contradiction. By application of the electrodynamic laws it has been found that when an electron possesses an acceleration it must always emit radiation. A consequence therefrom is the demand that absolute stationary electronic movements, *e.g.* the accepted motions of an electron round a positively-charged nucleus, are impossible, since the energy loss by radiation always destroys the stationary character of the motion. As above mentioned, however, such absolute stationary electronic orbits must exist in atoms, and the author here investigates the apparent contradiction. He shows that the demand that every electronic acceleration should give rise to radiation rests upon an inadmissible generalisation, which has originated during the mathematical treatment of the problem. The author now derives a new formula which shows that the energy-change of the system depends only on the change in the absolute value of the electronic velocity, and not as in the earlier formula on the change in direction of the velocity. The question now arises whether the new formula, $-dE/dt = 2/3 \cdot e^2/c^3 \cdot (v)^2$, essentially changes the problem of atomic radiation. According to this formula circular electronic orbits are not bound up with energy radiation, while with other orbits, on the contrary, radiation must ensue. The general result obtained is, therefore, that at the absolute zero where no radiation can occur, only circular electronic orbits are possible. At higher temperatures it is not possible to assert without further definition that circular orbits are stable and other types not. According to statistical mechanics every part of the ether which is in contact and in equilibrium with matter at a finite temperature possesses a certain energy. The atomic electrons are therefore always under the influence of external forces in addition to the attraction forces of the nucleus. If the atom be regarded as an electric field within which the electrons move, then a statistical equilibrium is to be expected between the atomic forces and the external forces of the medium, whereby the electrons at one time approach the nucleus and at another depart from it while describing ellipse-like or quasi-circular orbits. The elliptical orbit can arise equally well with the circular, only the orbit must always be undergoing change of form. The actual facts, however, are not so simple, since unknown conditions arise which compel the electrons to move in quite special orbits. When the latter are ellipse-like they may be assumed to be exact for a short time, and similarly with quasi-circular orbits. The time during which the electron pursues a special course has nothing to do with the kind of radiation emitted. Only the energy corresponding to the particular orbit defines the radiation, and immediately the electron assumes a special orbit it acquires the energy corresponding to the orbit.

In a previous paper the author has sought to render atomic radiation explicable on the assumption that the formula, $-dE/dt = 2/3 \cdot e^2/c^3 \cdot (v)^2$ [where v is the electronic velocity given as a function of the time t, E the energy, e the electronic charge, c the velocity of light], obtained from Maxwell's equations was valid. He now concludes that there must be present in the atom another as yet undetermined function—a nucleus function—whereby electronic radiation becomes compensated. The constraint which produces special electronic orbits must be traced to the activity of this function. The problem is thus rendered much simpler since the unknown nucleus function does not require to be connected with radiation. In a postscript the author points out that the difference between the two formulæ is very slight, and that it is not excluded for a further and more comprehensive correction to be necessary; at all events the above addition has to be made if the energy principle is to be satisfied. H. H. Ho.

654. *On the Quanta Theory of Radiation.* **A. Einstein.** (Phys. Gesell. Zürich, Mitt. No. 18. 1916. Phys. Zeits. 18. pp. 121–128, March 15, 1917.)—The remarkable similarity in shape of the curve for the chromatic distribution of temperature radiation with Maxwell's velocity-distribution law led Wien to a more rigid determination of the radiation expression. The present state of physical knowledge, however, leads to the conclusion that no assumptions based upon classical mechanics and electrodynamics suffice for the establishment of a complete radiation formula, but of necessity lead to Rayleigh's expression. In consequence Wien's formula becomes invalid, and Planck by the assumption of energy elements has produced an expression which is a better representation of the data. The present author from the standpoint of the quanta theory now puts forward an explanation of the relationship between Maxwell's curve and that of chromatic distribution, and throws a considerable amount of light on the obscure mechanism of emission and absorption of radiation. Planck's formula, $Q = av^3/e^{h\nu/kT} - 1$, is evolved by a very simple and general procedure. The condition was also found that the distribution of the internal energy of molecules must be brought about by absorption and emission of radiation only. The average kinetic energy acquired by a molecule (per degree of freedom) in a Planck radiation field of temperature T is found to be kT/2 and independent of the nature of the molecule and also of the absorbed and emitted frequencies. In the present paper the author shows that these conditions are sufficient for the development of his elementary hypotheses concerning emission and absorption. Section I deals with the fundamental hypotheses of the quanta theory and develops the canonical expression for the distribution of state. Section II considers hypotheses on the energy exchange by means of radiation. In Section III Planck's radiation law is derived. Section IV contains methods for the calculation of molecular motion in the radiation field. Section V is concerned with the evaluation of the gas-constant R. In Section VI the impulse communicated to molecules during radiation processes is considered. In Section VII the results are collected and from them a quanta theory for molecular behaviour is developed.

The author, in conclusion, remarks that almost all theories of temperature radiation are based upon the consideration of processes between radiation and molecules, and in general only with energy-exchange without taking into account the infinitesimal impulse actions. It is only by a consideration of the latter effects that a proper rigid theory can be developed. H. H. Ho.

SOUND.

655. *Acoustic Efficiency of Fog-signal Machinery.* **L. V. King.** (Frank. Inst., J. 183. pp. 259–286, March, 1917.)—The first section of this paper sketches the history of fog-signal experiments, dwelling specially on the work of Tyndall published in 1874 in a Trinity House report.

At about the same time experiments by Duane and by J. Henry were conducted and were published in 1874. The result of fog-signal tests carried out in the United States to the year 1894 were published in Livermore's Report to the Lighthouse Board of that date.

In 1901 a committee of the Trinity House carried out, at the Isle of Wight, a series of tests under the scientific direction of Rayleigh and T. Matthews. For calm weather a low note (about 180 per sec.) was considered most suitable; when the wind was contrary and the sea rough it was found that a higher note penetrated further than a low one. The physical significance of this was discussed by Rayleigh at that time (Phil. Mag. 6. pp. 289–305, 1903). It appears surprising that while a blast is being sounded from a siren which can be heard about 8 miles away on a good day energy is being expended at the rate of about 100 h.p. The high note of a Scottish signal required 600 h.p. Rayleigh raised the question as to whether these enormous powers are really utilised for the production of sound or whether from some cause, possibly avoidable, a large proportion may not be wasted.

The experience of French fog-signal engineers was summed up by C. Ribière in 1908. This emphasised the desirability of obtaining further knowledge as to the efficiency of the fog-signal apparatus.

The second section deals with the production of sound by a special siren called the *diaphone*, due in its present form to J. P. Northey. The essential feature of this apparatus is a hollow cylindrical piston which is oscillated longitudinally by the "driving-air," and so opens and closes ports which allow a series of puffs from the "sounding-air." These puffs give a nearly pure tone of about 180 per sec. This sound passes through a suitable horn.

The third section is occupied with the numerical relations between sound waves and their audibility as fog-signals.

The fourth section deals with the *phonometer* due to S. G. Webster. This consists of a Helmholtz hollow cylindrical resonating chamber one end of which is pierced by a smooth hole communicating freely with the atmosphere while the other has a very uniform plate of the best mica obtainable (such as used in phonographs). The resonator is tuned to the pitch for which it is to be used as a detector, and the vibrations of the mica diaphragm are detected and measured as follows: The mica disc carries a sharp steel point firmly clamped at its centre. A narrow steel strip is suitably held taut at both extremities in a fork capable of adjustment, and the strip has its centre in contact with the steel point so that a slight movement of the disc and point gives the strip a corresponding twist. This twist is detected by the movement of a beam of light reflected from a small concave mirror carried by the strip.

The diaphone may be worked backwards and is then called the "phone" or standard generator. When its diaphragm is made to oscillate through a known amplitude it is possible to calculate the numerical characteristics of

the spherical sound-waves emitted. By the use of the phone and the phonometer the acoustic output of any sound-generator of the same pitch (such as violin, cornet, or human voice) may be calculated.

Section five is on aerial sound waves of large amplitude and the discontinuity that may be expected to occur in their propagation. In the sixth section the thermodynamic estimate of acoustic efficiency is treated. By the use of resistance thermometers of iron wire 1/1000 in. in diam. the temperature-fall of the air, due to the conversion of compressed-air energy into sound, was measured in the diaphone.

Section seven deals with the actual fog-signal experiments carried out near Quebec in 1913. The acoustic efficiency of the diaphone in one case was found to be nearly 6 %, in another a little over 8 %. Using his phonometer A. G. Webster had previously found the violin, the cornet, and the human voice to have acoustic efficiencies of about 0·05 %, 0·1 %, and 1 % respectively.

An eighth section deals with future problems in acoustic engineering.

The paper is chiefly descriptive and includes many clear diagrams and other illustrations. Full details of the tests are to be published elsewhere shortly. E. H. B.

656. *Resonance Generated by Periodic Impulses.* **E. Budde.** (Phys. Zeits. 18. pp. 69–73, Feb. 15, 1917.)—Mathematical treatment in two parts dealing respectively (1) with impulses strictly, and (2) with the periodical drive by a series of strongly damped vibrations. Applications to intermittent tones, the singing of a tea-kettle, etc., are referred to. E. H. B.

657. *Propagation to Great Distances of the Sound of Cannonade at the Front.* **G. Bigourdan.** (Comptes Rendus, 163. pp. 323–324, Oct. 2, 1916.) —A cannonade produces various noises from the mouths of the guns and from the explosions of the shells. Some of these noises can reach great distances, 200 km. to 300 km., but it is not yet agreed how they reach them.

It is thus thought desirable to cite the case of an engineer aged 52, totally deaf since the age of 6 through cerebro-spinal meningitis. Placed at the side of a locomotive whistling, he perceived only a sudden pain of the drum skin which ceased immediately in spite of the continuation of the whistling. For the last 20 years if within 1000 m. to 1500 m. of gunfire, he perceives two successive shocks, one transmitted by the earth, one by the air. The last affected the thorax particularly. At the commencement of the Somme offensive, from the outskirts of Paris, when attending he was conscious of vibration during the cannonade; sometimes he would perceive only dull blows, at others he would perceive something at the same instant as an ordinary hearer. The distance to the Somme front (120 km.) excludes entirely the route through the air, so it must be by the earth; and so also for the normal hearer since both perceive it at the same time. [See Abs. 1056 (1916).] E. H. B.

658. *Audition of Distant Cannonade.* **F. Houssay.** (Comptes Rendus, 163. pp. 350–352, Oct. 9, 1916.)—Recounts the places and distances from which sounds have been heard, viz., Marne 40 km., Soissonnais 100 km., Picardie 130 km., Artois 200 km., Champagne 200 km., Verdun 245 km.

E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

659. *The Calculation of the Maximum Force between Two Coaxial Circular Currents.* **H. Nagaoka.** (Math. Phys. Soc., Tokyo, Proc. 9. pp. 85–93, April, 1917.)—F. W. Grover [see Abs. 716 (1916)] has calculated the force of attraction between two coaxial circular currents in terms of Jacobi's q-series.

The author has previously shown how expansions obtained in similar problems in q-series of ϑ-functions converge very rapidly. He now gives solutions, which, if they had been obtained prior to Grover's, would have lightened very considerably the labour of computation. The solutions will prove very useful to check Grover's results, and in direct calculations when the dimensions of the coils are exactly known. It is also pointed out that the results will be useful in connection with the theory of atomic configuration.

A. R.

660. *Re-determination of the Electron and Related Constants.* **R. A. Millikan.** (Nat. Acad. Sci., Proc. 3. pp. 231–236, April, 1917. Phil. Mag. 34. pp. 1–30, July, 1917.)—This re-determination of the most fundamental of physical constants was entered upon three years ago for three reasons. First, in 1913 results were published from Vienna which, though obtained by a modification of the author's method, were wholly irreconcilable with those found by the author. Second, a tendency developed, especially amongst British physicists, to adopt a value of e about 2 % lower than the author's. Third, the electron has recently taken on added importance because it has been found to carry with it not merely all molecular and atomic magnitudes as heretofore, but also all of the most significant of the radiation constants, such as Planck's h, the Stefan-Boltzmann constant σ, the Wien constant C_2, all X-ray constants, *i.e.* the wave-lengths of characteristic X-rays, etc. It seemed worth while, therefore, to drive the author's method to the utmost limit of its possible precision, for the method is exceedingly exact if its validity is granted.

The method used in the re-determination is the same as in the previous determination, but the apparatus is new throughout and every constant entering into the value of e has been re-determined with increased care and precision. That portion of the investigation which has to do with the testing of the general validity of the method has been reported in detail elsewhere. No indications whatever are found that the method, when properly used, ever fails, or that it ever even remotely suggests the existence of a sub-electron. The precision of the method is sufficiently attested by the consistency of the results on the 25 different drops, provided no constant error inheres in the measurement of the dimensions of the condenser, the volts, the time, or the viscosity of the air. There is but one drop which yields a value of $e^{2/3}$, differing from the final mean value by as much as one-third of 1 %, and the probable error of the mean computed by least squares is one in 4000. The new value of e, computed solely from the new data obtained in this re-determination, is exactly the same as that published in 1913. But the uncertainty in this value should now be no more than 1 in 1000.

A summary of the most important constants fixed by this determination

of e, together with the uncertainty attaching to each, is shown in the accompanying table with which the paper concludes.

Quantity.	Symbol, Value, and Uncertainty.
The electron	$e = (4{\cdot}774 \pm 0{\cdot}005) \times 10^{-10}$
The Avogadro constant	$N = (6{\cdot}062 \pm 0{\cdot}006) \times 10^{23}$
Number of gas molecules per cm.^{3} at 0° C. and 76 cm.	$n = (2{\cdot}705 \pm 0{\cdot}003) \times 10^{19}$
Kinetic energy of translation of a molecule at 0° C.	$E_0 = (5{\cdot}621 \pm 0{\cdot}006) \times 10^{-14}$
Change of translational molecular energy per 1 deg. C.	$\epsilon = (2{\cdot}058 \pm 0{\cdot}002) \times 10^{-16}$
Mass of hydrogen atom	$m = (1{\cdot}662 \pm 0{\cdot}002) \times 10_{-24}$
Planck's element of action	$h = (6{\cdot}547 \pm 0{\cdot}013) \times 10^{-27}$
Wien's constant of spectral radiation	$C_2 = (1{\cdot}4312 \pm 0{\cdot}0030)$
Stefan-Boltzmann constant of total radiation	$\sigma = (5{\cdot}72 \pm 0{\cdot}034) \times 10_{-12}$
Grating space in calcite	$d = (3{\cdot}030 \pm 0{\cdot}001)$ Å.

E. H. B.

661. *Some Aspects of Lord Kelvin's Life and Work.* **A. Russell.** (Inst. El. Eng., J. 55. pp. 1–17, Dec., 1916. Eighth Kelvin Lecture. Electrician, 78. pp. 216–219, Nov. 7, 1916. Abstract.)—This lecture should be referred to in its entirety as the subject-matter cannot be dealt with in a brief abstract.

L. H. W.

662. *Effect of Terrestrial Relief on Ionic Densities in the Atmosphere.* **P. L. Mercanton.** (Terrest. Magn. 22. pp. 35–37, March, 1917.)—It is known that the ratio of positive to negative ionic charge densities is greater at elevated points on the earth's surface than at lower levels. The experiments here described were made at the Tour de Gourze, near Lausanne, which stands at the summit of a hill 930 m. above sea-level. The ionic charges were measured by means of an Ebert apparatus charged to 50–240 volts, which would thus catch only the more mobile ions. The potential gradient at the top of the tower attained 1200 volts/m., and here the ratio $E_+/E-$ was found to be much above unity ; in one case E_- was zero. Within the tower where the potential gradient was zero E_+ was approximately equal to E_-.

J. S. Di.

663. *Observations of Atmospheric Electricity during the Total Solar Eclipse on October* 10, 1912, *at Boã Vista, Brazil.* **W. Knoche** and **J. Laub.** (Terrest. Magn. 21. pp. 171–204, Dec., 1916.)—Observations or records of the following were obtained for periods from Oct. 2 to 11 :—Hertzian waves, Radio-active content of air, Fall of potential, Conductivity (both + and −), Positive and negative charge, Number of ions (+ and −). Throughout the eclipse the sun was completely obscured by clouds, and the meteorological elements scarcely changed, so that it is supposed that the results obtained are independent of any indirect effect which might be produced by fluctuations of the meteorological elements.

The chief results produced by the eclipse were : The + and − charge, and the total number of ions showed a diminution followed by a recovery. The ratios of + to − charge, of + to − velocity of ions, and of + to − conductivity showed pronounced maxima, which occurred after the moment of totality. The + and − and total conductivity and air-earth current showed minima shortly after the time of totality. [See Abs. 101 (1917).] R. C.

DISCHARGE AND OSCILLATIONS.

664. *Conduction of Electricity through an Ionised Gas. "Bronson" Resistances.* **W. F. G. Swann** and **S. J. Mauchly.** (Terrest. Magn. 22. pp. 1–21, March, 1917. Paper read before the Am. Physical Soc., April, 1916.)—In many radio-active investigations in which the measurement of small currents is involved the principle of allowing the current to enter an electrometer and escape through a standard high resistance has been adopted, the deflection attained by the electrometer in the equilibrium state being the quantity which is directly measured, and which is proportional to the "unknown" current, when the standard resistance obeys Ohm's law. Bronson has developed a convenient type of resistance in which air between two parallel plates is rendered conducting by covering one of the plates with a layer of polonium [Abs. 816 (1905)]. These resistances obey Ohm's law over a considerable range, but their magnitude is such that for plates 5 or 6 cm.^{2} in area they give currents of the order 10^{-2} e.s. unit for a p.d. of 3 volts. For some purposes very much higher resistances are required under circumstances where it is undesirable to make the electrometer very sensitive.

Experiments are now described in which the distance between the electrodes in "Bronson" resistances is varied, as well as the radio-active material between the plates.

Conditions are finally obtained in which a linear relation exists between the current and the p.d. between the electrodes in the case of very high resistances. To obtain this relationship the upper electrode is made in two parts.

A. B. W.

665. *Light Excitation by Slow Positive and Neutral Particles.* **A. J. Dempster.** (Nat. Acad. Sci., Proc. 3. pp. 374–376, July, 1916.)—The only papers on this subject are by Stark and Wehnelt, who detected a luminosity, probably due to positive rays, with p.d. as low as 50 volts across the discharge tube. Also the Doppler-effect with canal rays in hydrogen shows a dark space between the displaced and undisplaced lines which may be explained by assuming that those particles in the rays which have less than a certain speed (corresponding to between 50 and 80 volts fall of potential for hydrogen atoms) are unable to excite light.

The author investigates the production of light by slow-moving neutral and positive rays. These are formed by ionising hydrogen by electrons from a Wehnelt kathode. The positives so formed pass through a slit in a plate behind the kathode into a second chamber, where the light emission can be studied.

It is concluded that slow positive rays are still able to excite light, certainly with a speed corresponding to less than 5 volts. Neutral rays also act similarly at slow speeds. The lowest p.d. at which neutral rays are detected is 50 volts, and it is possible that 50 volts is a lower limit at which the light excitation by neutral particles commences. The observations indicate that light emission may occur directly as a result of collisions between neutral particles and neutral molecules of gas. T. H.

666. *Lichtenberg Figures and Condenser Radiation.* **S. Mikola.** (Phys. Zeits. 18. pp. 158–165, April 15, 1917.)—A method is described of obtaining, photographically, beautiful Lichtenberg figures. The photographic plate is used to separate the two condenser plates, and when a disruptive discharge passes the figures are obtained on developing the plate in the usual way.

Theoretical considerations lead to the conclusion that these figures are due to electric radiation between the condenser plates when a disruptive discharge takes place. A number of photographs of the figures obtained under various conditions are reproduced. A. W.

667. *Unstable States in Arc and Glow.* **W. G. Cady.** (Am. Electrochem. Soc., Trans. 29. pp. 593–604 ; Disc., 605–612, 1916.)—The characteristic curve of a gas discharge is first discussed, with particular reference to the points of instability and to the condition for a stable discharge at any current. Experiments are then described on the different forms of arc, using carbon or metallic electrodes. The effect of impurities in the electrodes is shown to be a concentration of the discharge. A type of discharge is described in which there is an arc at the anode though only a glow at the kathode. Under certain conditions a metallic kathode may become so heated by the discharge that it vaporises freely without the formation of an arc. This is shown to have a bearing on the theory of the arc. Intermittent discharges, rotations in the iron arc, "glow-arc" oscillations, and the singing arc are considered in the light of the characteristic curve and of the conditions for stability. A peculiar effect of harmonics in the singing arc, using coupled circuits, was observed. When the oscillations are such as to extinguish the arc at each cycle the wave-form is very complex, and the second harmonic is often prominent. A carbon arc was made to sing by connecting a large capacity and a self-inductance coil of low resistance in parallel with it. A second coil was connected to a capacity such that the natural period of the secondary circuit was nearly the same as that of the arc circuit. When the two coils are brought near together, the pitch of the arc changes, owing to the effect of the close coupling. If the pitch falls, it can be made to reach an unstable value, from which it suddenly jumps a whole octave, the discharge remaining stable at the higher pitch. The explanation of this is to be found in the presence of a strong second harmonic, and when the two circuits are closely coupled this becomes reinforced to such an extent as to assume the rôle of the fundamental frequency. A. W.

668. *Electrolytic Phenomena of the Molybdenite Detector.* **M. J. Huizinga.** (K. Akad. Amsterdam, Proc. 19. pp. 512–513, 1917.)—The author has tried to demonstrate the existence of a secondary e.m.f. in unipolar crystals after the primary current has ceased. A current of some milliamps. was passed for some time through a crystal contact, the electrodes of which were connected to a galvanometer after stopping the current; this was repeated with a reversed primary current. In the case of molybdenite-brass the galvanometer deflection was very large, even when the primary current had passed during part of a second only, but in all other cases it was negligibly small. The deflection changed in direction and magnitude when the primary current was reversed. Rough electrometer observations indicated that the e.m.f. must have been at least 0·7 volt. Such an e.m.f. can hardly be explained by thermoelectric forces.

When, after many experiments with the same contact, a small dark-coloured spot had begun to show round about the brass point, the place of contact was observed by means of a microscope during the passage of the primary current. Again, a piece of molybdenite was floated on mercury while a Pt point pressed against it. On a current of some milliamps. being sent through the contact from MoS_2 to Pt, then, after some moments, in some cases after some minutes, a small quantity of a dark-blue liquid, in which

small gas-bubbles rise, appeared on the surface of the crystal. In one case, for instance, the strength of the current was 6 milliamps., the impressed e.m.f. being 3 volts. If this e.m.f. between crystal and Pt fell below 1·3 volts the disengagement of gas could no longer be seen. If the e.m.f. of 3 volts was reversed the current was only 0·5 milliamp.; the disengagement of gas became less, and could no longer be seen when the e.m.f. fell to 2·0 to 2·5 volts. The experiments prove that in the contact Mo–Metal, an e.m.f. exists, due to polarisation, in consequence of electrolysis. The phenomena, as described above, exactly agree with those obtained if the Pt point is brought into contact with the Mo not directly, but by means of a drop of acidulated water.

I. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

669. *Change of Conductivity of Minerals by Illumination.* **T. W. Case.** (Phys. Rev. 9. pp. 305–310, April, 1917.)—Besides selenium, stibnite, and cuprous oxide, certain other substances show an instantaneous response to varying illumination. Over 150 crystalline minerals were examined by exposing them to intermittent illumination from an arc lamp while in circuit with 110 volts and a three-step audion amplifier. The effect was judged by the loudness of the musical note corresponding to the frequency of interruption. The new light-sensitive substances thus discovered are: Iodynite—AgI—, silver oxide—Ag_2O—, the simple sulphides of Bi, Mo, Ag, and Pb, and certain compounds of either Pb or Ag with sulphur and either Sb or As, known as pearceite, miargyrite, jamesonite, boulangerite, bournonite, pyrargyrite, proustite, stephannite, and polybasite. Bismuthinite—Bi_2S_3—is classed as "very good," though its resistance is over a megohm in a mm.-cube.

E. E. F.

670. *Contact Resistance between Conductors in Relative Motion.* **V. Henry.** (Roy. Soc. Canada, Trans. 10. pp. 135–143, March, 1917.)—Describes a method of measuring the contact resistance between an arrow-pointed needle and a disc rotating at different speeds. Both needle and disc were made of the same alloy of silver and gold and measurements were carried out at various speeds of rotation of the disc for various pressures of the needle upon its surface. The speed/resistance curves given in the paper show that the contact resistance increases in proportion to the speed, and that it is inversely proportional to the pressure applied. J. W. T. W.

671. *Contact Resistance in Oil.* **H. E. Reilley** and **V[iolet] Henry.** (Roy. Soc. Canada, Trans. 10. pp. 145–150, March, 1917.)—Describes measurements of the pressure required to produce a low contact-resistance between wires of different metals when these are in air and also when the contact is immersed in different kinds of oil. It is found that the pressure is reduced in all cases of oil immersion, and, further, that drying the oil still further decreases the required pressure. J. W. T. W.

672. *Electrical Resistance of Nickel-Copper-Chromium and Nickel-Copper-Manganese Alloys.* **F. M. Sebast** and **G. L. Gray.** (Am. Electrochem. Soc., Trans. 29. pp. 569–578, 1916.)—An investigation of the effect of adding different proportions of Cr and Mn to Cu-Ni alloys. For the Cr series four sets of alloys were made up, containing 5, 10, 15, and 20 parts of chromium respectively, per 100 parts of Cu plus Ni. A few specimens were made up later, containing 25 parts of Cr per 100 parts of Cu plus Ni. The effect of the addition of pure Cr to pure Cu was that the resistivity of Cu was only slightly

increased, while the effect of the addition of pure Cr to pure Ni was a very greatly increased resistivity. For any single Cu-Ni alloy the resistivity first rises and then falls off, upon the addition of Cr. At a certain Cr concentration a max. resistivity is attained for each Cu-Ni alloy, and as the concentration of the Cu in the alloy increases, this maximum approaches the axis of zero chromium. In all cases, when the resistivity of an alloy was increased by the addition of Cr, the temperature coefficient was reduced, and *vice versa*. An alloy of very high resistivity (112 microhms-cm.) and of negligible temperature coefficient (0·000078) was found. This alloy would appear to have good commercial possibilities.

Three sets of alloys were made up containing 5, 8, and 15 parts of Mn respectively, with 100 parts of Ni plus Cu. The addition of manganese to an alloy of Cu and Ni at any concentration causes an increase of resistivity. Increase of resistivity is again accompanied by decrease of temperature coefficient, and *vice versa*. The curves obtained indicate that there is an alloy containing approximately 55 Cu, 45 Ni, and 15 Mn, which has a resistivity of about 70 microhms-cm. and a temperature coefficient of zero at 20° C. This alloy is a better resistor than those at present in use for precision apparatus.

J. W. T. W.

673. *Free Electrons in Metals.* **F. v. Hauer.** (Phys. Zeits. 18. pp. 149–151, April 1, 1917.)—Treats, on the electron theory, of the relations between the resistances of metals, melted and solid, and their dependence on the specific heats, the latent heats, and the temperature coefficients of the resistances of these metals. For this ratio the calculated and observed values are given as follows :—

Metals.	Ratio of Resistances, Liquid and Solid.	
	Calculated.	Observed.
Lead	1·66	1·9 to 1·95
Cadmium	1·89	1·8 to 1·97
Potassium	1·44	1·44 to 1·69
Sodium	1·36	1·35 to 1·70
Mercury	1·3 ?	4·04 to 4·9
Zinc	1·96	2
Tin	2·18	2·10 to 2·21
Antimony	<1	0·7

E. H. B.

674. *Cobalt as an Element for Thermo-couples.* **O. L. Kowalke.** (Am. Electrochem. Soc., Trans. 29. pp. 561–568, 1916.)—Cobalt possesses many advantages over nickel as an element in thermo-couples. When exposed to hot gases, particularly products of combustion, Ni becomes extremely brittle and breaks easily. On the other hand Co remains malleable and ductile.

Combinations with cobalt as one element, and "nichrome," "advance," "constantan," iron, and nickel-iron respectively, as the other, were tested for permanency after various periods of heating to 750° C. All the couples showed some change, but the combination cobalt-constantan was found to be the best of the group.

The cobalt element became coated with an oxide film which increased in

thickness with the duration of heating : the iron element suffered most from oxidation. E. G.

675. *New Phenomenon connected with Thermoelectricity and the Thermal Conductivity of Metals.* **C. Benedicks.** (Comptes Rendus, 163. pp. 751–753, Dec. 11, 1916.)—The author's "agglomeration" hypothesis [see Abs. 1453 (1913)] has led him to the conclusion that the Wiedemann-Franz law is not admissible. In a homogeneous metal unequally heated, a strong electric current may originate, and in consequence of the Thomson-effect cause a considerable transport of heat. The existence of such a current can be demonstrated by the following apparatus. Two similar copper (Kahlbaum) rectangles *a*, *a'* are soldered to circular discs *b*, *b'* of the same material on the right of the central line of the Fig., but on the left there is no contact between rectangles and discs. Near to the discs are fixed wires *c*, *c'*, and the temperature of either disc may be raised by the heat radiated when a current passes through the wire. The system is suspended in a horizontal magnetic field, and deflections may be observed by a mirror. When the upper disc is heated a current circulates and the suspended system is deflected. The current is in such a direction that in consequence of the Thomson-effect the thermal conductivity is apparently increased. The direction of deflection changes when the lower disc is heated or when the magnetic field is reversed. With a suspended system of constantan the deflection is opposite to that with the copper apparatus; the order of magnitude of the effect is the same as that of their respective Thomson coefficients. With an apparatus of lead no effect could be observed. A thermoelectric motor based on this phenomenon is also described.

Another deduction made by the author is that the thermal conductivity of a material depends on its form. The thermal conductivity of a copper cylinder composed of 1755 wires, 0·070 mm. in diam. and insulated from one another was found to be smaller than that of a solid cylinder of the same material and section and having the same electrical conductivity. The subdivision of the metal will diminish the magnitude of the currents which arise, in accordance with the author's view.

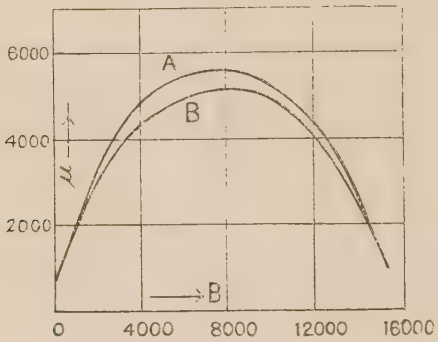
In the classical thermoelectric experiment of Seebeck the one metal was replaced by the subdivided metal (copper), and a deflection of the magnet of 25° was obtained on heating the junction. So large an effect cannot be ascribed to differences in composition of material. Thermoelectric effects may be tabulated thus :—

	Circuit.	
	Heterogeneous.	Homogeneous.
1. A difference of temperature gives rise to an electric current.	Seebeck 1823.	Benedicks 1916.
2. An electric current gives rise to a difference of temperature.	Peltier 1834.	Thomson 1856.

L. L.

ALTERNATING CURRENTS AND MAGNETISM.

676. *The Measurement of Magnetic Permeability.* **A. W. Smith.** (Phys. Rev. 9. pp. 414–418, May, 1917.)—A ring of iron magnetised by a current in a surrounding solenoid does not instantly reach its full magnetisation. This "viscous lagging" has been investigated by Ewing, Rayleigh, Jouaust and others. The question arises how much of the changing flux is measured by the ballistic galvanometer in the usual method. Such a galvanometer, with a period of 16 secs., will have completed its first throw in 4 secs. and cannot measure any change occurring after that time. The author has used a ballistic galvanometer of the d'Arsonval type with a period of 40 secs., which was critically damped on a circuit of 70,000 ohms. Used on a circuit of a few ohms resistance it took 13 mins., when deflected, to return half-way back to zero. In the neighbourhood of the zero it was practically stationary. The flux to be measured is reversed; this gives a quick deflection, at the end of which is a slow increase combined with a return drift to zero. After it has drifted back for 30 secs. or longer and reached some definite point on the scale the flux is again reversed. The galvanometer is deflected back a little



beyond its zero and the slow increase is noticeable, but the drift in this position is negligible. After allowing 30 secs. for the flux to reach its final value the scale is read and this return throw is taken as the deflection. A ring of Swedish iron 2 cm.² cross-section was examined with this galvanometer and with an ordinary ballistic galvanometer. The values of the permeability computed from these two sets of measurements are shown in the Fig. The higher curve (A) was obtained with the new galvanometer and the lower (B) with the ordinary ballistic galvanometer. To obtain more information regarding the cause of this slow magnetisation a ring of 1/8th the section was cut from the original. Both galvanometers gave the same result, although the permeability was lowered. After annealing the permeability rose to almost the initial (A) value. The author concludes that the slow increase of magnetisation is due to eddy currents in the iron, these currents tending to shield the interior portions of the iron from the changes in the field impressed by the current in the surrounding solenoid. L. L.

677. *Time Lag in Magnetisation.* **A. W. Smith.** (Phys. Rev. 9. pp. 419–424, May, 1917.)—When a bar of iron is magnetised by a current in a surrounding solenoid there is a time lag in the rise of the induction from the outside surface to the centre of the bar. The magnetising force at the surface is $H = 4\pi I$ [I = c.g.s. current turns per cm.] and that at the centre

at any instant may be written $H' = 4\pi (I - J)$, where J is the eddy current in c.g.s. units per cm. length of bar. The author assumes that the induction B at any instant is the same at all points within the bar and obtains by elementary analysis $H' = H (1 - e^{-\sigma t/\mu' \pi a^2})$. σ is the specific resistance of the iron and πa^2 the sectional area. $\mu' = B'/H'$ is of the nature of a differential permeability. Owing to the assumptions made in the theory the coefficient of the exponent is too small. Rayleigh's more rigorous investigation gives $e^{-1{\cdot}44\sigma t/\mu' \pi a^2}$. The result is often quoted to show that the effect of the eddy currents dies out too quickly to account for much of the observed "magnetic viscosity." J. J. Thomson computed that for an iron rod, 1 cm. radius and $\mu = 1000$ the induced current will fall to $1/e$ of its max. value in 2/9 sec. For soft iron, μ' may be as large as 12,000, in which case 1 % of the eddy current will remain after 10 secs. Ewing explains the time lag of magnetisation as largely due to the smaller relative amount of surface on the larger bars and the longer chains of molecular magnets. In a fine wire the breaking up of molecular groups starts at so many points that it is quickly completed. To further elucidate the effect of eddy currents the author has carried out tests on four rings of Swedish iron employing the galvanometer cited in the preceding Abstract. Two of the rings had an external diam. of 15 cm., while the internal diam. of the other two was a little greater than 15 cm. The cross-section of each ring was 1 cm. × 1·2 c.m. They could be placed over one another so as to form a single large ring (section 2·1 cm. × 2·5 cm.) separated by air-gaps of about 1 mm. The hysteresis loop for the compound ring was identical with that of each of the single rings. The time-lag of magnetisation was investigated by a pendulum apparatus which closed the galvanometer circuit at any desired interval after closing the battery circuit. The lag of the primary magnetising current was negligible. For a field of 2·2 gauss the flux reached its final value in 1·4 secs., rising to 0·8 of its final value in 0·58 sec. If the lag is due to magnetic viscosity it should make no difference if the air-gaps separating the four rings were made electrically conducting. The amount of iron surface bounding the rings would remain unchanged if these conductors are not magnetic. To test this, copper rings were fitted between the component iron rings and the whole soldered into one solid ring. Although the permeability was lowered, probably by the treatment involved, the time lag of magnetisation was more marked, rising to 0·8 of its final value in 2·05 secs. The rings of Swedish iron were also magnetised by a field of 12·4 gauss and the lag was in the direction to be expected from the lowered permeability.

The author concludes from his experimental results that the lag is an eddy-current effect and not due to magnetic viscosity. L. L.

678. *The Magneton as a Function of the Planck Constant.* **T. Wereide.** (Ann. d. Physik, 52. 3. pp. 283–288, April 3, 1917.)—To explain atomic radiation the two following definitions must be regarded as of general validity :—(1) In any emission process which is performed in a short period of time the relation between the radiant energy ΔU and its vibration-frequency ν, is equal to Planck's constant h; that is, $\Delta U/\nu = h$, and is independent of the nature of the emission, and also of the vibration frequency before and after emission of the radiated electrons. (2) An electron has a definite path within the atom, which path is particularly stable, and when circular satisfies the equation $mvr = Th/2n$, where m is the mass of the electron, v its velocity, r the circular radius, and T a whole number. Of these definitions the first is so simple that it may be deduced from other physical

considerations, but the second is dependent on the first although it has not as yet been possible to establish the connection in a concrete manner. In a previous paper [Abs. 908 (1916)] attention has been drawn to the fact that the second definition fits in with the magneton theory if both the Coulomb and the Ampère electromagnetic laws be assumed to hold for the electronic ring. A close connection must therefore exist between Planck's constant h and the magneton μ. Only one of these two magnitudes can in consequence be a fundamental physical quantity. In the present paper the exact relationship between h and μ is determined to be $\mu \times \frac{1}{5} he/4\pi m$. Following this mathematical exposition comes a discussion of the importance of this result for the explanation of the second equation of condition (Bohr's) referred to above. H. H. Ho.

679. *Magnetic Determination of Avogadro's Constant.* **T. Wereide.** (Ann. d. Physik, 52. 3. pp. 289–290, April 3, 1917.)—According to the experimental measures of K. Onnes, Weiss, and others, the magnetic moment per gm.-atom is a multiple of 1123·5. Consequently the magnetic moment per atom must be a multiple of an elementary quantum. This quantum, the *magneton,* is $\mu = 1123{\cdot}5/N$...(1), where N is Avogadro's constant. The determination of the number 1123·5 is regarded as very exact. From the above relation it follows that the constant N may be calculated if the magneton μ is determined independently from magnetic measures.

In a previous paper [see preceding Abstract] the following expression was established: $\mu = 1/c \,.\, 1/5\ he/4.\pi m$...(2), where h is Planck's action element, e the charge and m the mass of an electron, and c the speed of light. From the two equations we find $N = 1123{\cdot}5 \times 20\pi cm/he$. Thus, writing $c = 3 \times 10^{10}$, $m = 9{\cdot}00 \times 10^{-28}$, $h = 6{\cdot}414 \times 10^{-27}$ (Planck's value) and $e = 4{\cdot}774 \times 10^{-10}$ (Millikan's value), it follows that $N = 62{\cdot}2 \times 10^{23}$. E. H. B.

680. *Rapid Variations in Earth's Magnetic Field.* **H. Bell.** (Terrest. Magn. 21. pp. 205–208, Dec., 1916.)—No systematic method appears to be available at present for determining simultaneously very rapid changes in all three components of the earth's magnetic field. Ebert has outlined a method found to be successful for recording rapid changes in the vertical component [Abs. 1577 (1907)]. The present paper shows that by a slight extension of Ebert's method it is possible to determine with accuracy the motion of the magnetic-force vector during *normal* days, and also the motion of the vector during a magnetic storm. A method is also described for determining the speed of a magnetic disturbance.

Three wire coils are employed, perpendicular, respectively, to the three components of the magnetic vector, each coil being in series with a sensitive galvanometer. Suitable dimensions are suggested for the apparatus, which is thought to have some advantages over the suspended needle instruments in being less liable to disturbance from mechanical or temperature causes, but it only gives the rate of change of element. In magnetic storms use could be made of a high-resistance Einthoven galvanometer of very short period.

C. P. B.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

681. *The Chromoradiometer of Benoist for measuring the Penetrating Power of X-rays.* **G. C. Trabacchi.** (N. Cimento, 12. pp. 130–132, Sept., 1916.)—The degree of hardness read in a radiogram is in all cases higher than that which can be observed with the naked eye. When using the fluorescent

screen laminæ of Al, Cd, Ag, and Pd are gummed upon a thin card, and radiographs are obtained through the two halves of the same pellicle, one with a reinforcing screen, the other without a screen. The tube was in both cases in precisely the same condition, and the exposure was regulated by obtaining the same degree of blackening of the negative in a control exposure through the card. The results given show that the blackening of the negative under the Al is the same with as without the screen when the exposure is the same, but with the other three metals the blackening without the screen is always noticeably less than with the screen. This helps to confirm the given explanation of the phenomenon. A. E. G.

682. *New Method of Localisation by Radioscope.* **Mongie.** (Archives d'El Médicale, 25. pp. 183–192, April, 1917.)—The apparatus here has for object the abolition of the use of the radiographic plate and diminution of the number of necessary observations. The apparatus required for localisation is reduced to (1) a ribbon of lead 1·5 mm. in thickness, 30 mm. in width and of variable length—sufficiently long to encircle the part of the body under observation, (2) two brass buckles, (3) a dermographic pencil, (4) a vertical screen with tube arranged so as to give a horizontal ray. The wounded should be placed as near by as possible in the same position as during the operation. Full working instructions, with the necessary diagrams, are given. A. E. G.

683. *Localising Foreign Bodies with X-rays when Normal Incident Ray and Height of Tube are not known.* **Mazérès.** (Comptes Rendus, 164. pp. 177–179, Jan. 22, 1917.)—The method here described enables an extra-rapid localisation of projectiles to be made when the normal incident ray and the distance from the focus to the plane of projection, plate, or screen are unknown. For this purpose a metro-radiographic scale with an automatic interpolation arrangement is employed. The method is to place the wounded between the bulb and the screen. Let O be the image of a prominent point of the ball B. Two different metallic markers are fixed upon the skin at the points P and R of entry and exit of the ray which passes by B. The three images of B, P, R coincide in O, which is marked upon the free edge of a sheet of paper placed upon the screen. The bulb is displaced 10 cm. parallel to the screen, when the three images separate to *r*, *b*, *p*, which are also marked on the edge of the paper. These observations give all the necessary data, and from them it is shown how to obtain the depth, etc., of the projectile with the apparatus employed. Working instructions and also a theoretical discussion of the method are given. A. E. G.

684. *Experimental Researches on Electro-vibrators.* **D. Omodei.** (Archives d'Él. Médicale, 25. pp. 153–182, April, 1917.)—This paper deals in detail with the work which has been done on this method of localising pieces of shell, etc., in the wounded by means of the electro-vibrator. The subject is considered in the following sections :—The nature and structure of the core, its form, section, and length ; The coil used for magnetisation ; Method of suspending the vibrator ; Nature of the current employed ; Value of the intensity of the vibratory action ; Relations between nature of current, dimension of core and the number of turns in the exciting solenoid ; Three standard models of the electro-vibrator ; The auto-ambulance electro-vibrator ; The vibration of non-magnetic metals ; Electro-vibrators with resonance. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

685. *Cutting and Chipping of Glass.* **A. Pollard.** (Engineering, 103. p. 410, April 27, 1917.)—The use of the diamond in dividing glass, though said to date from the sixteenth century, is one of those industrial processes less heeded than it deserves.

Rayleigh's interesting letter [Abs. 262 (1917)] has whetted the appetite of many for a paper on this difficult subject. Hertz's theory and his diagram of the lines of principal stress in the neighbourhood of a compressed area on the surface of an elastic solid certainly helps in the expectation of what may happen in rupture. But it would appear that the edge of a cutting diamond sinks into glass before the rift takes place, and this may modify Hertz's diagram.

If a glass surface be ever so lightly covered with soot from a smoky flame and then the diamond drawn across the smoked surface with various degrees of pressure, the path of the diamond presents a curious appearance under the microscope. The track is generally made up of two parts, one with just a surface layer of soot lightly swept away, and a narrower part in the centre of this with the soot particles pressed into close contact with the glass. This narrower, or true track appears to be due to the diamond edge actually sinking into the glass and squeezing the soot against the sides of the elastic trough so formed, for the breadth of this track depends upon the pressure, and varied from 0·035 to 0·004 mm. in the author's experiments. When the pressure was enough to cause a rift the surface-cracks on the glass did not appear to extend beyond the boundary of the true track laterally, and in the $\frac{1}{8}$-in. plate glass used, only when the track exceeded 0·030 mm. did the glass rift. The author has never seen a diamond rift without its attendant surface-cracks. Sometimes the thin and transparent sooty layer in this true track assumes a beautiful appearance, not unlike the backbone of a fish with the vertebral spines and ribs directed towards the advancing edge of the diamond.

The "hiss" of a good diamond doing its work, and the beauty of the scalloped border of the cut are remarkable. Is the former due to the discontinuous velocity of the front edge of the snapping rift as the diamond uniformly advances? With what speed does a rift travel, and to what depth? E. H. B.

686. *High-temperature Investigations.* IX. *Preparation of Zirconia Articles.* **O. Ruff** and **G. Lauschke.** (Zeits. Anorg. Chem. 97. pp. 73–112, Sept., 1916. Engineering, 103. p. 530, June 1, 1917.)—A crude (83·5 %) and a purified zirconia (98·75 Zr_2O_3) were used, the latter being baked at 5 temperatures between 750° and 2400° and the products, of density 5·7 to 4·99, kept apart; the temperature of baking is important. Small cylinders were prepared by mixing the material with water and also 1 % of starch. Melting-points were determined in a Ruff vacuum electric furnace: Zirconia 2563°, lower in hydrogen at high pressure; SiO_2 1850°, yielding a white bead; glucina (beryllia) 2410° (no vapours); MgO evaporated above 2000°; Al_2O_3 2005 to 2008° (no vapours); thoria, ThO_2, white mists above 2400, not melted at 2780°; yttria, Y_2O_3, 2410° (vapours above 2350°). The melting-point of zirconia was lowered by the addition of most of these oxides, but raised by ThO_2 and Y_2O_3. Crucibles of zirconia and 1, 3 or 6 % of other oxides, water

and starch were pressed between dies in straight cylinders up to 45 mm. high, 3 mm. wall thickness, baked in a Hessian crucible and further heated for 70 min. up to 2400°. Carbide formation proved almost unavoidable in the latter case; to diminish it, the crucibles were placed within crucibles of crude zirconia which suffered in their turn; oxides volatilised from the outer crucible condensed on the inner. The crucibles changed in shape and colour at high temperatures, increased in strength (especially if baked at low temperature), shrank and developed larger pores. On subsequent heating in the oxidising blowpipe flame the mottled colours turned into yellow-red, and most of the crucibles crumbled because the carbides and lower oxides were oxidised; crucibles baked at 2000° stood the oxidation better than those baked at 2400°, and crucibles containing 6 % Al_2O_3 proved strongest. The few crucibles which stood this test were finally heated to the highest temperature attainable and then analysed; the analyses, and especially the separation of Zr from Y or some unknown compound, proved very difficult. The addition of other oxides to the zirconia should be adapted to the temperature at which the zirconia is to be baked; if at 2000°, add 1 % Al_2O_3; at 2200°, 1 % ThO_2; at 2400°, 1 to 3 % Y_2O_3; larger additions increase the porosity, which magnesia and glucina reduce; in general glucina, magnesia, and silica are not recommended. H. B.

687. *Volatility of Gold at High Temperatures in Atmospheres of Air and other Gases.* **W. Mostowitsch** and **W. Pletneff.** (Russian Metall. Soc. J. No. 3. pp. 410–421, 1915. Met. and Chem. Eng. 16. pp. 153–154, Feb. 1, 1915. Abstract.)—The results of experiments on the volatility of chemically pure gold showed that at temperatures between 1100° and 1400° C. the metal is not volatile in atmospheres of pure air, O, N, CO, or CO_2. In a stream of hydrogen the volatility first becomes noticeable at 1250° C. and rapidly increases with the temperature and time of heating. Since gold is not volatile in other gases its vaporisation in hydrogen is ascribed to the formation of a volatile hydride, Au_2H_2. F. C. A. H. L.

688. *Manganese-Gold Alloys.* **L. Hahn** and **S. Kyropoulos.** (Zeits. Anorg. Chem. 95. p. 105, 1916. Rev. de Mét. 14E. pp. 27–30, Jan.–Feb., 1917.)—As the manganese attacks porcelain and oxidises, the mixed metals were rapidly fused in porcelain tubes (electrically heated) at 1300° C. and cooling curves taken. The beginning of the crystallisation was better defined than the end. The resulting curves show a well-pronounced maximum roughly at 1200° for 50 % Au, and two minima, also well defined, at about 1050° and 950° for 32·5 and 77·5 % Au (all percentages atomic). The alloys are grey up to 62·5 % Au, and then become yellow. The Au-Mn alloys form dendritic crystals surrounded by polyhedric crystals richer in gold and increasing in size with the gold percentage. The dendritic crystals of up to 10 or 20 % Au are more attacked, by acetic or nitric acid, in the centre than near the circumference. The 30 % Au alloy showed when polished a relief structure indicating a hard eutectic surrounded by softer alloy; this structure disappeared and became homogeneous on annealing at 1000° for 1 hour. The rate of diffusion of Au and Mn seems to be very slow, but could not be accurately determined, as prolonged heating to 1000° oxidised and volatilised the manganese. Alloys of 55 % Au and less are very brittle; above 62·5 % they can be forged and cut with the saw. The authors do not agree with Parravano (Soc. Chim. Ital., Gazz. 45. i. p. 293, 1915) as to the alloys rich in Mn; but their own form contained 5 % of Al, and Parravano does not give any

analysis. The authors confirm Tammann to a certain extent as to the solubility of the alloys in acids. As with Tammann's Au-Ag and Au-Cu, there was, when HCl served as solvent for the Mn-Au alloys, a slow and a rapid reaction, and their curves approached Tammann's theoretical curve. H. B.

689. *The Ternary System Iron-Boron-Nickel.* **N. Tschischewsky** and **S. Mikhailowsky.** (Russ. Metallurg. Soc., J. i. pp. 547–559, 1915. Rev. de Mét. 14E. pp. 16–21, Jan.–Feb., 1917.)—The iron-boron alloys appearing both very hard and brittle, the authors attempted to combine increased hardness and tenacity by adding a third metal, nickel. The attempt proved only partly successful. The materials were fused together in a Tammann electric furnace in about 20 mins. and cast in rods of 40 to 45 gm. weight. The use of ferro-boron with 19·56 % B and 0·17 C is preferable to the use of amorphous boron, which catches fire at 700°. In the analysis the alloys were dissolved in sulphuric acid, the Fe and Ni deposited (electrolytically) as mercury amalgams, and the Ni was then estimated by means of dimethylglyoxime; the sulphuric acid and boric acid were titrated. The Brinell hardness-tests of the binary Fe-B alloys show that the hardness increases up to 2 % B, decreases between 2 and 2·4 % B, and increases again with from 2·4 to 4·32 % B. The addition of Ni further increased the hardness of the alloys without altering the trend of the curves. In forging tests the Fe-B alloy with 4·32 % B could still be forged at dark-red heat, whilst the 2 % alloys were already brittle in the cold. The addition of Ni again increased the shortness; iron with 4·4 % B and 4·8 Ni could not be forged, and an iron with 4·24 B and 10 Ni crumbled under the hammer. At lower temperatures, however, some ternary alloys could be forged; the higher the Ni percentage, the lower should be the temperature, and some of these very hard alloys might be utilised. It is suggested that the brittleness of the hot alloy is due to an increase in the proportion of the fusible eutectic surrounding the crystals of hard solution, and that the addition of Ni further increases the proportion of eutectic. H. B.

690. *Physico-chemical Conditions of the Metallurgy of Zinc.* **M. Bodenstein.** (Phys. Zeits. 18. pp. 107–108, March 1, 1917. Paper read before the Deutsch. Bunsen Gesell., Dec., 1916.)—The reduction by carbon of the carbonate of potassium (to K and CO) and of zinc oxide (to Zn and CO) should be analogous, being of the nature of a sublimation which ought to set in at a temperature where the gaseous products of the reactions can overcome the external pressure. It is striking, however, that the temperatures of formation of the two metals differ but little, although the heats of combustion (Zn 86,000 cals., K 281,000 cals.) differ greatly. The relations are explained by Nernst's heat theorem. In his experiments the author first determined the temperature at which the system ZnO + C "boils," *i.e.* at which there is a vigorous liberation of CO and zinc vapours. Calculating the heat balance of the reactions from the change of this "boiling-point" with pressure, the author obtained impossible figures. The reaction (2ZnO + C) would not explain the difficulty either, although it seems to accord with technical observations. He therefore concludes that the values observed do not represent equilibria, but only points at which the reactions became sufficiently rapid for the methods of measurement applied. Real equilibrium pressures were then determined in quartz-glass apparatus of 20 cm.³ charged with (ZnO + C), the evolved gas pressing on fused lead which was balanced by nitrogen. Equilibrium was reached very slowly (sometimes after days) at pressures ranging from 4·6 to 1253 mm. Hg for temperatures from 596° to 995° C.

Exact calculations are not possible so far, since the equilibrium of CO, C, CO_2, and of Zn vapour at low temperatures is not known. Metallurgically, liquid zinc might be obtained at ordinary atmospheric pressure, but it would be a very slow process. H. B.

691. *Effect of Time in Reheating Hardened Steel below the Critical Range.* **C. R. Hayward** and **S. S. Raymond.** (Am. Inst. Mining Eng., Bull. No. 122. pp. 277–285, Feb., 1917. Mech. Eng. 39. p. 307, April 20, 1917. Abstract.)—Bars of steel containing 0·45 % C, 0·056 % Mn, 0·03 % Si, 0·049 % S, and 0·016 % P were quenched in water from 800° C. and subsequently reheated for various periods of time at temperatures of 300°, 400°, 500°, and 600° C., after which their mechanical properties were determined. The results indicate that after the steel has been heated through at any particular temperature, increasing the time of tempering has little or no effect on the resulting mechanical properties. F. C. A. H. L.

692. *Temperature of the Reversible A1-transformation in Carbon Steels.* **K. Honda.** (Tôhoku Math. J. 5. pp. 285–295, Dec., 1916.)—Thirteen kinds of carbon steels containing from 0·14 to 1·5 % carbon have been studied by observing the change of intensity of magnetisation [Abs. 1161 (1916)] during the critical ranges at extremely slow rates of heating and cooling. The results are summed up in 16 diagrams and a table, and indicate that with normal rate of heating and cooling the interval Ac1–Ar1 varies from 40 to 120 deg. C., which is reduced to 9 to 50 deg. C. on very slow cooling. At very slow rates of heating and cooling Ac1 is very nearly constant (725° to 730° C.), while Ar1 varies from 679° to 721° C. for all percentages of carbon. The difference was found to depend on the content of impurities, so that the change is reversible in pure carbon steels only. In pure carbon steels the reversible A1 change occurred at 727° C., and with extremely slow rates of cooling and heating Ac1 should coincide with Ar1. Ar1 was found to be independent of the max. temperature previously attained on heating. The magnetic transformation of cementite was found to occur in all the steels at 210° C., and the author proposes to designate this temperature the Ar0 point. F. C. A. H. L.

693. *Temperature Measurement in Bessemer and Open-hearth Practice.* **G. K. Burgess.** (Bureau of Standards, Technol. Papers No. 91 [29 pp.], Washington, 1917. Am. Inst. Mining Eng., Bull. No. 122. pp. 293–306, Feb., 1917. Mech. Eng. 39. p. 498, July 13, 1917. Abstract.)—The most satisfactory type of pyrometer for temperature measurement in steel-furnace practice is an optical pyrometer using monochromatic light and permitting observations to be made from a distance. The necessary corrections for emissivity are well known in the cases of metal and oxides, but are somewhat uncertain in the case of slags. It was not found practicable to determine the temperature of the charge in a Bessemer converter by pyrometric methods. In the open-hearth furnace, however, it is possible to control the temperatures of the roof, the metal, and the slag by pyrometric operation, but there is no essential relationship between the temperature of the furnace roof and that of the metal. F. C. A. H. L.

694. *A Method for measuring the Viscosity of Blast-furnace Slag at High Temperatures.* **A. L. Feild.** (Bureau of Mines, Techn. Paper No. 157 [27 pp.], 1916.)—The work described in the paper forms part of a general investigation of slag viscosity, its variation with temperature and composition of the slag, and its effect upon the distribution of sulphur between molten iron and

slag. A method of measuring viscosities up to 1600° C. has been worked ou on the lines originated by Margules, who confined the liquid between tw concentric cylinders, revolved the outer one at a constant speed, and dete mined the torque exerted on the inner cylinder. The experimental result indicate that the viscosity of normal blast-furnace slag flowing from th cinder notch at 1500° C. is 250 (water at 20° C. = 1). The average valu derived from 8 different slags is 301. Highly acid and highly basic slags ar more viscous at any particular temperature than intermediate slags. Hig alumina content causes decrease in the initial softening temperature, b exerts no appreciable effect on the viscosity at higher temperature Temperature/viscosity curves are given for eight slags of widely differe compositions. All the curves approximate in form to a rectangula hyperbola. F. C. A. H. L

695. *Viscosity of Blast-furnace Slag.* **A. L. Feild.** (Am. Inst. Minin Eng., Bull. No. 122. pp. 307–332, Feb., 1917.)—The main portion of the wo dealt with in this paper has been described in the preceding Abstract. study of the temperature-viscosity relations of synthetic slags is being carrie out, and it has been shown that replacing lime by magnesia results in th lowering of the viscosity at all temperatures. The author also discusses th application of viscosity data to blast-furnace operations and desulphurisatio processes. The value of an iron ore depends upon the possibility of it being made to yield economically a slag of desirable fluidity and desulphu ising power ; the viscosity relations are therefore of importance in determinin the optimum conditions from the standpoint of economy. F. C. A. H. L

696. *Constitution of Mixed Crystals.* **L. Vegard** and **H. Schjelderup** (Phys. Zeits. 18. pp. 93–96, March 1, 1917.)—A large number of substance possess the ability to form mixed crystals, and, while such are usuall isomorphous, the connection between isomorphism and miscibility is never theless not simple, and from time to time has entailed considerable discussion For instance, Retgers regards the phenomenon as purely mechanical, mixe crystals being formed of series of thin homogeneous laminæ ; on the othe hand, Wulf, Gossner, and Tutton have shown that the magnitude of th molecular volume plays a decided part in the formation of mixed crystals, i that the molecular volumes of both substances must not be widely differen this being a necessary condition for the miscibility. The latter has led to th view of an intimate union between the two components. Although Gossn states important grounds for this latter assumption the situation is sti obscure, and Retger's view may yet be correct, inasmuch as the propertie of finely stratified substances have not been very exactly established.

With the aid of the experimental means afforded by the Röntgen rays, i is now possible to make further progress into the structure of mixed crystal Should the latter be composed of thin homogeneous laminæ, then eac component must possess its own Röntgen spectrum, and, in consequence the spectrum of the mixed crystal will be a superposition of the componen spectra. The other possibility is for the mixed crystal to behave as an entity in which case the atoms of both components would take their place in combined configuration, and a different Röntgen spectrum result. Th authors have carried out a whole series of experiments based on this stand point, using Bragg's reflection method, the four cases examined being thre sets of mixed crystals formed by varying numbers of molecules of potassiu bromide and potassium chloride, and one case of potassium and ammoniu

bromides. The crystals were not chemically analysed, but estimated from the concentration of the solution by means of Foch's curve. The mixed crystals were found to reflect as single entities, and to give normal spectra, *i.e.* no superposed spectra with double maxima, but a single maximum with a reflection angle lying between those of the two components. A table and a curve are included. The authors then give a detailed discussion on the constitution of the mixed crystal. The space-lattice of the pure components is constructed of a definite number of lattice elements, and in the mixed crystal a new configuration arises with a corresponding change in the volume of the lattice element. The molecular volume, however, of the two components is adjusted through the atomic forces (forces of crystallisation). A mathematical discussion is given of the atomic arrangements necessary for new reflection maxima to ensue. It is shown that the lattice planes of the four atomic sets cannot all coincide, and the various cases which arise are investigated. H. H. Ho.

697. *The Kinetic Theory of Reaction-velocity.* **A. March.** (Phys. Zeits. 18. pp. 53–59, Feb. 1, 1917.)—Purely thermodynamic considerations are insufficient for the determination of the velocity of chemical reactions, since the time does not enter into the thermodynamic equations, while, in addition, the velocity not only depends on the nature of the reacting substances, but also on certain frictional resistances not comprehended in thermodynamics. In consequence a theory of reaction velocity is based by the author on the kinetic gas theory, and only touches on thermodynamics where the temperature functions for the two velocities of a reaction are to be referred to the equation of the reaction isochor. The first section deals with gaseous systems, the first case considered being that of a unimolecular reaction in which a dissociable gas is suddenly transformed from a state of very great pressure to one of very low pressure, the former case being such that the gas is practically undissociated and the latter that where almost complete dissociation ensues. Section 2 contains a mathematical investigation of the dissociation problem discussed physically in Section 1. In Section 3 the mathematical expressions established in the previous section are considered in conjunction with the equation of the reaction isochor. In Section 4, the conclusion is arrived at that for every compound a critical temperature exists above which no amount of pressure is sufficient to maintain the compound intact. Star-temperatures here receive brief attention. Section 5 deals with the effect of ions on reaction velocities. H. H. Ho.

698. *Electrical Conduction in Dilute Amalgams.* **G. N. Lewis** and **T. B. Hine.** (Nat. Acad. Sci., Proc. 2. pp. 634–638, Nov., 1916.)—The authors have determined the conductivity of solutions of lithium, sodium, and potassium, in various dilutions at about 20° C. They find that a small addition of potassium increases the resistance of mercury, an equivalent amount of sodium produces a less increase in the resistance, while the addition of lithium diminishes the resistance. When the volume changes produced are considered, it is found that when added at constant atomic volume, lithium would increase, and potassium decrease, the resistance of mercury. A. F.

699. *Exchange of Bases in Permutite.* [**Miss**] **G. Kornfeld.** (Phys. Zeits. 18. pp. 113–114, March 1, 1917. Paper read before the Deutsch. Bunsen Gesell., Dec., 1916.)—Together with V. Rothmund the author investigated the aluminate-silicates, or permutites, of Gans, considering them to

consist of two phases, a solution containing two kathions and one anion, and a solid phase (permutite) containing the two kathions. The author reviews the researches and formulæ of Wiegner and of Gans and describes experiments in which powdered sodium permutite was mixed with solutions of silver nitrate and sodium nitrate (simultaneously or separately), and shaken for about 5 minutes; the concentrations varied within very wide limits. A new formula is deduced and tested by experiments with silver permutite and alkali salts. H. B.

700. *Electrical Endosmose.* I. **T. R. Briggs.** (J. Phys. Chem. 21 pp. 198–237, March, 1917.)—The author gives a *résumé* of our present knowledge regarding electrical endosmose, together with a critical discussion of the various theories. It is considered that the most satisfactory is the adsorption theory of Freundlich-Bancroft, which agrees with the facts whenever these are accurately known. No new experiments or data are given. T. S. P.

701. *Contact Resistance of Metal Electrodes.* **N. K. Chaney.** (Am. Electrochem. Soc., Trans. 29. pp. 183–202; Disc., 202–206, 1916.)—The author bases an explanation of the high contact resistance observed between the zinc electrode and the electrolyte, on the supposed existence of a hydrogen film upon the electrode surface, which film is discharged there by local action between the zinc and the electrolyte. Experimental evidence is given in support of the explanation, and it is shown that the predicted behaviour of such a hydrogen film under selected conditions is in agreement with the observed behaviour of the contact resistance. In the hydrogen film it is assumed that there is an equilibrium between atomic and molecular hydrogen (compare Bennett and Thompson, ibid., 29. p. 269, 1916; Bancroft, ibid., 29. p. 301, 1916), and the bearing of this on overvoltage, contact resistance, and tendency to local action, is pointed out. T. S. P.

702. *Relation between Contact Potentials and Electrochemical Action.* **I. Langmuir.** (Am. Electrochem. Soc., Trans. 29. pp. 125–180; Disc., 181–182, 1916.)—The electrochemist usually considers that the chemical theory of electrochemical action, as distinct from the contact theory of potential, is a sufficient and satisfactory one. Within the last few years, however, it has been demonstrated that contact potentials of large magnitude do exist, even between pure metals in a practically perfect vacuum. The evidence for this, which is reviewed in detail, has been obtained by the study of (1) electron emission from heated metals, (2) photoelectric phenomena, (3) contact potentials. It is shown that several independent methods lead to values of the contact potentials which are in substantial agreement. Much of the difficulty which the electrochemist has had in reconciling the contact theory with the known intimate relation between chemical action and electrochemical phenomena, has been due to failure properly to define "potential difference" and "electromotive force." The author defines the former as the limiting value of w/e, when e decreases without limit, w being the amount of work which must be done to move an electric charge e between two points A and B, between which the difference of potential is to be measured; the "potential difference" is thus dw/de. "Electromotive force" is defined as w/e, where w is the work done when an electron (charge e) moves from one place to another. From these definitions a mathematical theory of the mechanism of the effect is developed. When only the e.m.f.'s of reversible cells are considered, it is not necessary to take into account contact potentials.

In dealing, however, with kinetic phenomena, such as overvoltage and passivity, or with effects due to single potential differences, the contact potentials must be an essential factor. Detailed consideration of these relations is reserved for a future paper. T. S. P.

703. *Tests of Tin Plating Baths.* **F. C. Mathers** and **B. W. Cockrum.** (Am. Electrochem. Soc., Trans., 29. pp. 405–410, 1916.)—The various baths for tin plating, which were described by Kern [Abs. 2019 (1913)], were prepared and electrolysed for two weeks with a current density of 0·4 amp./dm.^{2} (3·6 amps./sq. ft.) under the conditions recommended. In no case was a satisfactory deposit obtained ; in most cases the deposits were masses of more or less adherent crystals, although in some cases they were spongy. The Beneker bath, containing 25 gm. of sodium hydroxide, 10 gm. of stannous chloride, and 15 gm. of sodium thiosulphate in 200 cm.^{3} of water, gave the smoothest and firmest deposits of good thickness. The deposits were dark in colour, but could be scratch-brushed to a bright metallic appearance. The bath seemed gradually to deteriorate, the deposit becoming black, and at last non-adherent. This bath is considered to be far below the quality desired for electroplating. Some of the baths containing combinations of potassium cyanide and alkali carbonates or hydroxides, with a little stannous chloride, gave bright deposits, but there was a simultaneous liberation of hydrogen, and anode corrosion was poor. Such thin flashings cannot be called tin-plating. The best results were obtained with the stannous ammonium oxalate bath [see next Abs.]. T. S. P.

704. *Peptone as an Addition Agent in Stannous Ammonium Oxalate Baths.* **F. C. Mathers** and **B. W. Cockrum.** (Am. Electrochem. Soc., Trans. 29. pp. 411–414; Disc., 415–416, 1916.)—The addition of peptone to the stannous ammonium oxalate bath is essential for the production of a thick, smooth, finely crystalline deposit of tin. No other tin bath (except possibly the sulphide bath, which was not tried) is known from which such a thick, smooth deposit can be obtained. A good composition for the bath is : 5 % stannous oxalate, 6 % ammonium oxalate, 1·5 % oxalic acid, and 0·25 % peptone. The stannous oxalate is readily made by precipitating a solution of stannous chloride with oxalic acid. The bath is run at room temperature at 0·4 amp./dm.^{2} (3·6 amps./sq. ft.), and should be stirred at intervals. T. S. P.

705. *Addition Agents in the Electro-deposition of Silver from Silver Nitrate Solutions.* **F. C. Mathers** and **J. R. Kuebler.** (Am. Electrochem. Soc., Trans. 29. pp. 417–429 ; Disc., 429–432, 1916.)—Tartaric acid is the most effective substance for producing solid, firm deposits of silver from the ordinary silver refining bath containing silver nitrate and nitric acid. A good composition of the bath is 3 % each of silver as silver nitrate, of nitric acid, and of tartaric acid. The further addition of 0·01 % of glue twice daily makes the deposit much smoother and of a darker, more shiny colour. The addition of 2 % of ferric nitrate also makes the deposits much smoother, darker, and more shiny. Analysis of a kathode showed 0·086 % of iron. If economy in addition agents is desirable at the sacrifice of some smoothness in the deposit, 0·05 % of tartaric acid and 0·01 % of glue twice daily can be used. More tartaric acid must be added after about 100 gm. of silver have been deposited from each 100 cm.^{3} of solution, otherwise loosely adhering crystals are formed. A current density of 22·4 amps./sq. ft. (2·45 amps./dm.^{2}) in a vigorously stirred bath gave a firm, smooth deposit,

which was a little heavy at the edges. A current of 35 amps./sq. ft. (3·8 amps./dm.²) gave a firm deposit with still rougher edges. In a bath only gently stirred or mixed 7·4 amps./sq. ft. (0·8 amp./dm.²) gave the best results. With 6 % silver solutions, 14·8 amps./sq. ft. (1·6 amps./dm.²) could be used. The ordinary addition agents, such as glue and peptone, by themselves only partly restrained the crystalline structure, and did not produce smooth deposits. Metaphosphoric acid caused the deposit to be hard and non-crystalline, but the bath soon deteriorated. The weight of tartaric acid used up is 0·005 of the weight of silver refined. The deposit is brittle, and is thus of no value in plating. T. S. P.

706. *Rapid Nickel Plating.* **O. P. Watts.** (Am. Electrochem. Soc., Trans. 29. pp. 395–400 ; Disc., 401–403, 1916.)—The plating bath used contained the following weights of salts, in gm. per litre : $NiSO_4$, $7H_2O$, 240 ; $NiCl_2$, $6H_2O$, 20 ; H_3BO_3, 20. It was found that rapid plating could be carried out when the solution was heated at 25°–70° C., at which temperatures the current density could be increased to 2–2·5 times its usual value. Plating may be done at 200–300 amps./sq. ft. (22–23 amps./dm.²), when the same amount of metal is deposited in 5 minutes as requires 1½ hours in the "rapid solutions" now in use at 10 amps./sq. ft. The current efficiency, if less than 100 % in the cold solution, is increased on warming. Anode corrosion is greatly improved, and higher current densities may be used at the anode as well as at the kathode. Replacing the nickel chloride by sodium chloride still gives a very good plating bath, but such high current densities cannot be used. T. S. P.

707. *Nickel Plating.* **F. C. Mathers, E. H. Stuart,** and **E. G. Sturdevant.** (Am. Electrochem. Soc., Trans. 29. pp. 383–392 ; Disc., 393–394, 1916.)—The object of the authors was to find the nickel-plating bath which would give the best deposit at the highest current or voltage, and to discover the effect of each constituent of the bath on the plating operation. The conclusions arrived at are as follows :—The purest nickel anodes obtainable should be used. Strips of electrolytic nickel kathodes, 99·8 % pure, used directly as anodes, dissolve irregularly and with pitting, but no impurities are introduced into the bath. Very much of the trouble with badly coloured deposits and with sludge is caused by the iron from impure anodes. The addition of 2 % of magnesium or nickel chloride makes the anode corrosion approximately theoretical. The nickel anodes, supported by lead hooks, may be completely immersed in the solution, thereby greatly reducing the amount of scrap metal from the anodes, which should be placed in bags in order to catch loosened particles ; these particles cause pitting if they reach the kathode. The addition of 0·2–0·3 % of ammonium citrate keeps the solution clear and free from sludge, whereby a shallower tank and smaller volume of solution may be used. The bath should be stirred or mixed thoroughly at intervals, but not within 8–10 hours of the time of using, if any solid particles from the anodes are present. The greater the ratio of nickel sulphate to nickel ammonium sulphate the brighter and more shiny the deposit. The more acid the solution (to the point of acidity to Congo red) the more shiny the deposits. Boric acid increases the current that can be used without burning or blackening the deposit. The best composition for the bath is : nickel ammonium sulphate, 4 % ; nickel sulphate, 10–14 % ; boric acid, 1–3 % ; magnesium chloride, 2 % ; ammonium citrate, 0·2–0·3 %. A current density of 1·6 amps./dm.² (14·8 amps./sq. ft.), which plates a thickness of 0·0025 cm. (0·001 in.) in 1¼ hours, may be used. T. S. P.